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Forthcoming Events.

OCTOBER 3.

Society of Chemical Industry (Manchester Section):—Ordinary meeting at Manchester. "Chemistry and Industry," Paper by W. J. W. Woolcock.

Diesel Engine Users' Association:—Ordinary meeting in London. "The Significance of Exhaust Temperature," Paper by P. H. Smith.

Junior Institution of Engineers:—Meeting in London. "Explosions Terrestrial and Celestial," Paper by Prof. A. W. Bickerton, A.R.S.M.

OCTOBER 4.

Institute of British Foundrymen (Lancashire Branch):—Meeting at Manchester. "John Wilkinson," Paper by J. P. Bedson.

OCTOBER 6.

Society of Engineers:—"Pulverised Fuel," by E. Kilburn Scott.

OCTOBER 7.

West Yorkshire Metallurgical Society:—Annual general meeting at George Hotel, Huddersfield.

Institute of Metals (Birmingham Local Section):—Ordinary meeting at Birmingham. Chairman's address.

Institute of Metals (North-East Coast Local Section):—Ordinary meeting at Newcastle-on-Tyne. "The Structure of Metals in its Relation to Electric Failure," Part I, Paper by Professor F. C. Thompson, D.Met., B.Sc.

Sheffield Metallurgical Association:—Ordinary meeting at Sheffield. "Low Temperature Heat Treatments: Their Effects and Applications," Paper by H. Moore, D.Sc.

THE FOUNDRY TRADE JOURNAL IS THE OFFICIAL ORGAN OF THE INSTITUTE OF BRITISH FOUNDRYMEN AND THE WELSH ENGINEERS' AND FOUNDERS' ASSOCIATION.

Institute of British Foundrymen.

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Brunelli's Process.

Elsewhere in this issue there appears a translation of an article by Signor Ing. Cesare Brunelli, which we commend to the notice of all practical foundrymen. Allowing that Brunelli's ideas have lost a little of their best meaning in translation, it will be appreciated that he has studied closely the phenomena to be associated with the freezing of masses of liquid grey cast iron in a sand mould.

As Mr. Smalley is at present in the States, we will answer as far as possible some of the objections Brunelli has raised to the former's conclusions. Primarily, Smalley was not attempting to make sound castings of the two cylinders dealt with. He was exhibiting the force of liquation under a definitely set out series of conditions. He emphasised the importance of the presence of the phosphide eutectic, which in some cast irons is 15 per cent. of the whole. The importance of this is doubted by Brunelli, but surely this is a very important factor, especially when it freezes at a few hundred degrees Centigrade lower temperature than the bulk.

Brunelli emphasises the importance of the danger of pouring metal into partially open hot moulds, as they, by causing a chimney effect, favour the absorption of water vapour. We are convinced that Smalley would not allow an experimental mould of the character he described to take up moisture. He would, in fact, be well aware of the actual moisture content present. Thus we doubt if Brunelli's objection can "hold water."

A phase of Brunelli's work which is interesting is the rapid changing of the atmosphere in a closed mould, having large openings for runners and risers. He is obviously an observant individual, but stretching our imagination to the utmost we cannot visualise the entrance of atmospheric air once liquid metal has entered, except perhaps in the very largest of moulds teemed ridiculously slowly. However, we definitely admire his attempts to describe these very obscure phenomena, and such men, backed up by a few hundreds of practical foundrymen, would rapidly surround the foundry by a large number of metallurgists, instead of the over-worked handful at present doing such admirable work. The average ferrous metallurgist's knowledge of cast iron consists in a few orthodox notions such as sulphur is injurious, phosphorus increases the fluidity, and silicon controls the carbon. We have met ferrous metallurgists whose names are household words wherever steel is made, who have asked us "What is this semi-steel?" or "Is the centrifugal casting of cast iron practical?" Yet possibly these are the very men whose evidence in a high court case would be listened to with the greatest respect. Therefore let Brunelli, and as many other really practical foundrymen as possible, set down their observations, because our own cast-iron metallurgists—Turner, Rhead, Smalley, Young, Holmes, Hurst—are much more eager to help them along, by directing their thoughts along orthodox metallurgical lines, when they see a desire to help themselves.

The greatest failing amongst the practical men is an inability to express their full meaning and a disregard for definite data. For instance, Brunelli refers to a 30 per cent. addition of antimony. We are left wondering whether 3.0 or 0.3 is his actual meaning. If Brunelli has done nothing more than emphasise that filtering cast iron helps to prevent the incorporating of non-metallic inclusions his effort has been worth while, and one which is endorsed by the best modern metallurgical and practical thought.

Work of the German Foundrymen's Society in 1923-24.

Dr. Siegfried Werner, in his address to the annual general meeting of the German Foundrymen's Society in August, outlined the work of the Society during the past year.

Owing to the actual economic conditions in the country, the Society's members were faced with a great many difficult questions on the financial and economic side, and in this connection they have very usefully co-operated.

Technical progress during the year does not appear to have been as satisfactory as it might have been, and Dr. Werner remarks that in many respects the Germans are behind the English and Americans in the matter of up-to-date methods and equipment. Last year the Society offered a prize for the best work dealing with the question of heat economy in foundry drying-stoves, but no paper was submitted for the prize. The president seemed to think that foundries are not showing the amount of interest they ought to do in this and similar questions.

Reference was made to the formation of a new "Foundry Consultation Company, Limited," the object of this being to assist with expert technical advice those foundries that are neither big enough nor wealthy enough to engage one or more engineers themselves. Many of the bigger firms are associated with this new company, which is therefore enabled to give the best of advice to those who consult it.

Very unsatisfactory is the result of the prize competition instituted last year for the practical construction of castings. This is a question that has been employing the minds of most foundrymen for years now, but the prize competition has not brought forth any results which would lead to the adoption of generally applicable principles of design. Some papers were received which tend to consider the subject as a whole, and this is under consideration.

The work of the Society on the fixing of standards for obtaining definite mechanical strengths in castings has proceeded very slowly owing to the occupation of the Ruhr. A number of casts have been made in certain works, and it is hoped to arrive at the preliminary report stage by the next general meeting, but it will take two years to get all the results shipshape so as to enable definite information to be arrived at. A special sub-committee of the Society has been formed to deal with the utilisation of waste in foundries and preliminary bases of investigation have been laid down.

The Society has devoted a great deal of attention to the investigation and testing of moulding sands. The geological part of the work is well advanced and charts have already been drawn up in which the various known German deposits have been classified. Data are given as to whether the particular sand is suitable for iron, steel or other metal moulding sand. At the Hamburg Exhibition last year was shown the Treuheit-Gessersche process of testing moulding sands, and Treuheit's ball-pressure apparatus for determining the strength of stamped moulds. It is hoped to continue this work of classifying the various types of sands, and it is also hoped to obtain moulding sand synthetically by mixing ordinary silica sand with clay-binding media.

A certain amount of progress has been reached in standardisation in foundry work, and certain preliminary specifications have been submitted for approval. Most of these deal with patterns and pattern-making. The object of standardisation is that parts which are in constant demand should be obtainable at practically any foundry without a lot of waiting.

In conclusion, the President referred to the very important work of research being carried out in England by the British Cast-iron Research Association. The German Society supported as far as possible the German Iron Research Institution, which is doing similar work to the British Cast-iron Research Association; and, at the same time, a certain amount of encouragement and support are being accorded to the various technical and training institutions in the country engaged in the education of the future foundryman.

Corrosion-Resistance Alloys for Use in Acid Mine Water.*

By ROBERT J. ANDERSON and GEORGE M. ENOS.

Summary.

This Paper points out the importance of the corrosion problem to the coal-mining industry. The nature of acid mine water from coal mines is discussed briefly, it being pointed out that such water causes corrosion largely by reason of its content of free sulphuric acid. Typical analyses of acid mine waters from bituminous coal mines are given. The impracticability of attempting to neutralise acid waters underground is discussed.

The nature of the corrosion process in acid mine water is taken up, and the effects of the chemical composition of alloy meterials and of the formation of coatings on corrosion rates have been emphasised. A *résumé* is given of the results of tests carried out by the U.S. Bureau of Mines during the past several years on the corrosion of ferrous and non-ferrous materials in acid mine waters from coal mines. It is shown that all ordinary commercial grades of irons and steels are corroded rapidly by such waters. The results of simple immersion tests on 45 metals and alloys in waters from three mines are summarised, it being found that of all the materials tested, some five, namely, a high-chromium steel, two chromium-nickel-silicon steels, a high-silicon cast iron, and a nickel-chromium-iron alloy were quite resistant. The microstructural aspects of these various materials after corrosion have been studied, and their principal features are discussed. The results of accelerated electrolytic corrosion tests on the above materials are summarised, it being found that the order of losses of the materials is roughly the same in both long-time immersion and accelerated tests.

On the basis of the various tests made a list of materials which are resistant to acid mine waters has been drawn up, and the applicability of these materials to the construction of mining equipment is indicated.

A number of specific corrosion problems which exist at present in the coal-mining industry because of the presence of acid waters in mines is pointed out.

Correspondence.

[We accept no responsibility for the statements made or the opinions expressed by our correspondents.]

Ceylon Plumbago.

To the Editor of the FOUNDRY TRADE JOURNAL.

SIR,—Having read Mr. T. G. Hunter's article on "Ceylon plumbago" in the last issue of the FOUNDRY TRADES JOURNAL with great interest I take the liberty of asking you if you can furnish me with details regarding the manufacture of plumbago crucibles, or could any reader, through the medium of the FOUNDRY TRADES JOURNAL, enlighten me? Failing this, could you recommend any literature on this subject—Yours, etc.,

GEO. FORRESTER.

70, Mayfield Street, Springbank, Hull.
September 26, 1924.

C. A. HILL & COMPANY (Hilex Iron Company) have removed to more commodious premises. Their new address is Rilton House, 58-60, King Edward Street, Hull. The telephone numbers are now Central 4801 and 4802, whilst the telegraphic address—Ferrum Hull—remains unchanged.

MR. N. GRAHAM, who was until recently steel works manager to the Sociedad Espanola de Construccion Naval at Reinosa, Spain, is now occupying a similar position with the Stavanger Electro-Staalverk A.S., Jörpeland, near Stavanger, Norway. He is a graduate of Sheffield University, and has specialised in the manufacture of alloy steel by the electric arc process.

* A Paper read before the American Society for Testing Materials.

Sand-Blast Sand.*

By W. M. Weigel.

The use of the sand blast has increased rapidly during the past few years. It was formerly used almost entirely in the foundry to clean and remove inequalities from rough castings. This is still the most important application, but in addition, it is now employed for the removal of paint from old surfaces, carving and engraving on stone and marble, glass cutting, cleaning or renovating the walls of stone and brick buildings that have become discoloured, preparing the surface of metals for the electrolytic bath, putting the final finish to metal surfaces, and has even been proposed as a means of channelling or cutting out blocks of stone in the quarry.

Different Grades.

Some producers, especially those in the Central States, or when only one or two grades are produced, have trade names for the different sizes. In the Eastern States (U.S.A.) some attempt at standardisation has been made, and the grades or different sizes are numbered. Those commonly made are No. 1, No. 2, No. 3 and No. 4; No. 1 being the finest and No. 4 the largest. Some producers made a No. 0, but this is unusual, while some do not make No. 4, as their sand banks do not contain sufficient material of this size. In general, a No. 2, for example, of one producer, is approximately equal in size to a No. 2 of another. Although the same sized screens may be used, differences in their method of operation, slope, and whether wet or dry screening is used, as well as the characteristic shape of the sand grains, will make variations in the finished products.

Producers have, in general, their own line of customers who are familiar with the use of all the particular grade of sand they are using, and normally the producers would, at first, not see any advantage in uniformity of practice. It is not the intent or purpose of this paper to recommend standard sizes, but at the same time, it would seem advisable for the producers to get together and discuss this point. The following range of sizes is suggested:—

Sand No. 1.—Through 20 mesh on 35 mesh.
Sand No. 2.—Through 10 mesh on 28 mesh.
Sand No. 3.—Through 6 mesh on 10 mesh.
Sand No. 4.—Through 4 mesh on 8 mesh.

Screening is not perfect, so that small amounts of coarse and fine material must be permitted. A maximum of not over 2 per cent. failing to pass the coarser screen and not over 5 per cent. passing the finer screen, should make a satisfactory product and not be difficult to produce in a commercial way.

Shape of Grains.

Considerable difference of opinion exists as to the relative merits of sharp, angular grains and rounded grains. Advocates of sharp grain claim faster cutting and those of the rounded grain claim smoother work and longer life of the sand. That is, it can be used over more often and makes less dust. Many consumers have used only one kind, and are therefore not basing their opinions on fact. One consumer reported that they used a certain sand because it had sharp cutting angles, and they preferred it to the round. An examination of the sand showed it to be a decidedly rounded grain material.

All quartz grains have about the same hardness, but there is considerable difference in the "toughness" or ability to resist crushing and shattering. No method of testing this property other than actual use has been developed. The results of plant tests would be interesting, but on account of the many variables entering into the work, would be misleading unless carried out most carefully.

Application of Different Sizes.

No. 0 is little used. No. 1 is used for light work and where a comparatively smooth finish is desired, as for finishing automobile castings, finishing brass, frosting glass, and removing paint. A large manufacturer of pipe fittings, both brass and iron, uses No. 1 sand exclusively. No. 2 is used for similar work, but of heavier character. A manufacturer of enamelled bath tubs uses No. 2 sand only. Nos. 1 and 2 are the sizes mostly used. Nos. 3 and 4 are for the heaviest cast-iron and steel work only, very little No. 4 being used.

Mining and Preparation.

The main producing centres are New Jersey, Ohio and Illinois.

New Jersey produces both bank or lake and beach sand. Mining or recovery is by steam-shovel if the bank is above water level, and will not hold water for a dredging pond. If a pond can be made, the mining is usually done by hydraulic dredging with centrifugal pumps placed on a floating dredge, and discharging to the washing and screening plant through long pipe lines. In some localities, as on the sea beach, recovery is by locomotive cranes, equipped with clamshell buckets.

Washing of the sand is carried on in all cases. This may be only screen washing where the sand is particularly clean. Other methods include the use of sand cones, and helical screw washers of the Lewistown type.

In rare cases, the final screening or sizing is done wet, in rotary screens or trommels. This practice is unusual, as it involves the separate drying of each size. The usual practice is to dry the entire product after washing, or that portion of it taken out by wet screening to be sized to the various grades of blast sand. If only one size is made, it is usually by wet screening.

Both stationary steam dryers and revolving mechanical dryers are employed. The larger sizes, Nos. 3 and 4, are usually taken out by revolving screens of woven wire cloth. The finer sizes are separated on shaking or vibrating screens. At one plant, the products were screened twice to remove excessive over and under size, and make a uniform product. At another plant, sizes 1, 2 and 3 are separated on stationary sloping screens. A good product is made, considering uniformity, but the efficiency is low and plans are under way to displace the stationary screens with vibrating ones.

The Ohio and Illinois sands are obtained generally from more or less coherent sandstone. Those in Ohio usually require crushing. The Illinois deposits are less consolidated, and while they require blasting to loosen up the beds, disintegrate and fall to pieces in water sufficiently so that the material can be handled by dredging pumps.

Necessity for Washing.

All bank and beach sand contains silt or clay, which, adhering to the quartz grains, can only be removed by washing. Also, varying amounts of vegetable matter may be present, which would break up and pass through the screens with the finished sand. A small amount of clay adhering to the quartz grains does not, in itself, lower the usefulness of the sand. For proper use, however, the sand must be perfectly dry, otherwise it tends to choke in the sand-blast machines. The presence of clay or similar foreign matter may cause the sand to absorb moisture, and in this way cause trouble in its use. Also, the amount of dust made is increased, but this is a small objection as clay dust is much less injurious in all ways than silica dust.

Utilisation of Waste Blast-Sand.

In nearly all cases the sand is used over and over, until the grains are broken too fine to accomplish the desired result. The fan exhausting the air, sand and cuttings from the sand-blast room discharges to a collector of some form in which the dust is separated from the coarser material. If a coarse size is used originally, the finer sizes resulting from breaking of the grains may be separated by screening and used for suitable purposes. In many instances the dust is considered worthless and is thrown away. At foundries a use may often be found for this material, and the following suggestions have been made.

The United States Silica Company, Chicago, furnishes the following data on possible uses for waste sand-blast dust:—

1. As a foundry parting, it is shaken from a bag exactly as ordinary parting is applied.

2. Mixed with dead core or gangway sand it forms excellent cores, especially for this, difficult work.

* Extracted from the Reports of Investigations, American Bureau of Mines, to which the Author is attached as Mineral Technologist.

3. It can be used as a core wash in place of ordinary silica dust.

4. Under certain conditions, it can be used as a foundry facing, but the foundryman's judgment must be exercised in applying it to various classes of work.

5. It can be mixed with clay for luting the covers of annealing pots.

6. It has been employed successfully as an interlining between the brick flooring and the metal bottom of annealing and other furnaces. A layer of dry dust 1½ ins. thick imparts a cushioning effect to the brick floor which aids in preventing breakage under heavy loads. The sand also insulates the bottom of the furnace, which lengthens its life.

The waste sand also could be used as a mixture for making concrete, but as particles of iron and steel would lead to discolouration, it should not be used on work above ground. The sand also has been used for covering newly laid asphalt roads, with excellent results.

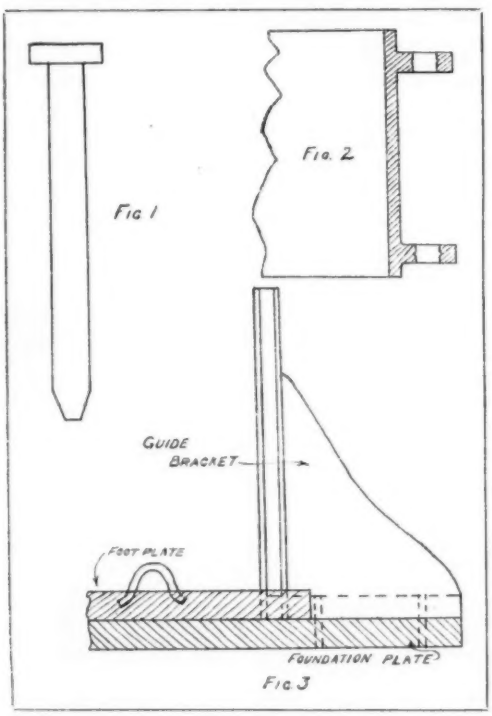
Moulding Box Pins.

By J. E. P.

It is difficult to realise that many foundries to-day use the old-fashioned moulding-box pin. Perhaps it is correct to say that very little improvement has been made in this direction; yet it is one of the most important factors in the foundry.

Away back in 1902 this question was raised in this journal, and a fairly good discussion followed; yet very little, if any, improvement has resulted therefrom.

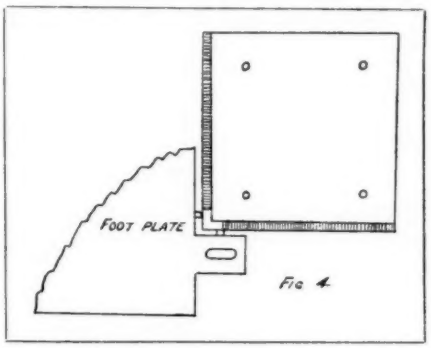
The old-fashioned pin is that which has a thread



and nut at the bottom to fix in the lower part of the moulding box. Sometimes these pins are straight and sometimes they are not, but they are always troublesome. Frequently three or four lugs are made on a moulding box, the holes drilled and the pins fitted, yet only *two* do the actual locating.

There are many kinds of moulding-box pins, but probably the one which commends itself to most foundrymen is the loose pin, Fig. 1. This has many advantages over the other old ones, and none of their disadvantages. Of course, all moulding boxes must have the pin holes made definitely interchangeable, and the writer has found great difficulty in getting these holes drilled perfectly correctly.

The best method to adopt when making moulding boxes, especially for repetition work—and probably it will be found economic in a jobbing foundry—is to cast the holes in the lugs of the box larger than the diameter of the pin to be used (Fig. 2), then set the boxes up quite square and flat, and place a mandrel in the centre of the cored holes, fixing it by means of a proper jig. A good hard metal can then be poured in the space between the mandrel and the lug, thus giving a perfect alignment of the holes. The diameter is obtained by the diameter of the mandrel, and the master loose pins, which are of the same diameter. Only a few pins are required for hundreds of boxes, thus obviating the necessity of two, three, or four pins to each box. Boxes without pins are much more easily and readily handled, full or empty. This system will save a very considerable amount of capital expenditure, and be far more effective than any other. Of course, standardisation should be obtained in all holes



throughout the whole foundry, whether the box is large or small.

In the case of very large loam work, where the mould to be lifted weighs many tons, pins of the foregoing description would be of little use, and the following cast-iron guide has proved most effective. These guides were used for a loam mould the top plate of which alone weighed 7½ tons.

Fig. 3 shows side view of guide bracket. It is made large and strong, according to requirements. It is bolted to a foundation plate. There are toggles or chipping strips each side, so that the cope may run smoothly during lifting or lowering. Fig. 4 is a plan view showing bolt holes in base strips and foot plate of cope.

Institute of British Foundrymen.

LANCASHIRE BRANCH (Burnley Section).

The first meeting of the session 1924-5 of the Burnley Section of the Lancashire Branch was held on September 16 at the Burnley Technical College, Mr. G. Barnes presiding.

In a brief presidential address the Chairman referred to the formation of a Junior Section in connection with the Lancashire Branch, and read the rules which had been framed for its guidance. He urged that young foundrymen should make full use of the opportunities afforded them by the Institute, and also by the educational authorities in classes for the study of foundry subjects. Such classes had been held at the Burnley Technical College during the last session, under the charge of Mr. J. Pell, whose abilities were well known to the members. In this way they were supplementing the training given in the foundry itself, but he was afraid the moulder did not always give the apprentice sufficient encouragement to take advantage of these opportunities.

WITH A VIEW to further developing the electric furnace business in France, French Possessions and countries under the protection of France, Automatic and Electric Furnaces, Limited, have formed "La Compagnie Française Wild-Barfield," with offices at 102, Rue Faubourg Poissonniere, Paris.

The Filtration of Cast Iron.

By Cesare Brunelli (Bergamo, Italy).

The author recently had occasion to read the interesting Paper presented to Paris Convention by Mr. Smalley.

The article, which dealt with the cast iron and mass effect, demonstrated that in the case of a given mass, liquid cast iron is liable to suffer from the effect of indeterminate elements, the liquation or segregation of which would determine the formation of porous or spongy cavities of an importance that is subordinate to the proportion of the factor "time of solidification." Amongst other experiments Mr. Smalley describes the results of a test carried out by him on two cylindrical blocks weighing about 156 lbs. each, and of identical form, which after sectioning showed up the presence of an internal draw.

Mr. Smalley observes that with one of the blocks in which the pouring was conducted centrally from the top, with a $\frac{1}{4}$ in. runner, without any riser, this block, even if it contains an internal draw or porosity, will result in perfect surface on machining. In the case of the second block no indication is given as to the pouring method adopted, or the results obtained. Although a large riser of 100 × 150 millimetres was placed upon it, the same internal draw, as in the first case, was obtained.

Mr. Smalley, basing his conclusions on the time taken for the complete solidification of the mass, and more particularly on the prolonged fluid state of the phosphorus content, apparently believes that such a prolongation could give time to the phosphorus to effect its own liquation when the other crystals were nearly solidified.

The author hesitated to join in the discussion at the time of the presentation of the Paper. He, however, does so now because Mr. Smalley has invited those interested to give their opinion on the different phenomena, and incidentally mentions the author as an authority on filter grates, and an advocator of the abolition of any form of riser—a process not always correctly described by some critics, who improperly christen it "a process of slow pouring," because filter grates bring about a "rain of shower pouring," with the idea of allowing the metal to free itself more easily from every impurity before passing in the mould.

In order to make Mr. Smalley's views more clear, the author considers the time ripe for a detailed description of his process, and that which follows is a translation of the introduction to a brochure which he has published containing a description of the Brunelli process. This introduction has the object of teaching the foundrymen that it is unwise to maintain old prejudices, and illustrates the opportunities now available of adopting modern methods.

Before, however, outlining the details of the instructions, the author would point out that he does not think Smalley's hypothesis of the liquation or segregation of the phosphorus in the cylinders to be correct for various reasons, because it is not possible that in so small a mass of metal there can be concentrated such an exceptional quantity of phosphorus. When the phosphorus combines with the metal the energy of its atomic movements is converted into heat energy, and this causes the atoms mutually to attract one another more strongly, and their combination results in a stronger aggregation, a factor that is obviously opposed to the internal draw encountered in the cylinders.

Internal draws or spongy places, even of considerable size, are sometimes observed in masses of larger or smaller size, when expanded air is allowed to collect in them, or when dry steam is present, produced by the water vapour developed by warm sand. Large rolls, however, remain free from any draw whatsoever if they are poured with specially filtered cast iron, and in a mould totally enclosed.

Principal Defects in Castings and their Causes.

The principal defects are caused by (1) the impurities introduced into the cupola with the charge quite often associate themselves with the molten cast iron; (2) the freedom usually allowed to such impurities to enter into the mould as a consequence of unsuitable pouring methods; (3) the ignoring of the peculiar expansion and contraction properties of cast iron, the compressive effect of which is often dispersed through the vents, risers and runners, and in no case should any outlet have a greater diameter than 9 mm.; (4) no mould outlet must communicate with the atmosphere; (5) an irrational distribution of the available heat, and (6) the erroneous conception of the manner by which defects are caused.

The difficulties indicated are all overcome by the use of filter grates. Once the technique of introducing into the mould only the true constituents of cast iron is understood there will no longer be any fear of the formation of draws, or the danger of the presence of slag or porosity. For this reason, the use of risers, which is always of an empirical character, can be discarded entirely. All communication with the atmosphere is eliminated, as the filters when in use form a seal. Such conditions therefore allow the exploitation of the advantage indicated by (3); prevent trouble outlined by (4); regulate (5); and avoid (6).

Impurities in the Raw Materials.

Eminent metallurgists have treated thoroughly of the changes that take place in the blast furnace and their influence on the resulting pig-iron. There is no doubt, however, that a careful choice of the raw material, and a rational control of the cupola blast, would improve the metal. However, not all foundries are in a position to pick and choose their raw materials, nor can they have at their disposal special apparatus. They author is convinced from his long experience in large foundries making castings for steam engines, pumps, motor cars, machine tools, rolling mills and hydraulic machines, etc., that it is much better to take care of the absence of a standardised liquid metal by separating the impurities by filtration, considering this as a practical and positive means of guaranteeing continuous success.

Cast iron, coke and coal, of no matter what origin, are always more or less mixed with sulphur and earthy oxides, and the scrap to be remelted renders their condition still worse. When the cupola lining is in good condition, the resulting product is better, but if it is used after it is worn out the metal becomes worse and worse. The fact is, that this material through having lost its efficiency becomes porous and liable to absorb sulphur gases with which it becomes saturated.

The layer of ganister which is plastered over the lining is destroyed by these gases. The ganister becomes detached, mixes itself with the slag, and some of it is kept in suspension in the liquid iron which thus becomes fairly oxidised.

The deterioration in the condition of the metal is increased by the way in which the cupola charges are introduced. Another similar factor is poor control of the slag. Every time the metal is withdrawn the slag is liable to be entrained, and its subsequent release is problematic. The slag is removed haphazardly; sometimes it leaves the surface of the bath uncovered, the carbon of which is thus exposed to the oxidising action of the blast. The carbon is often changed into large graphitic flakes, of which a part is burnt, producing small bright flames, while the rest passes into the mould, thus damaging the castings.

More to be feared are the various combinations of the silicious aggregates (non-metallic inclusions). The small blueish white flames that burn on the surface of the metal in the ladles, indicate the presence of such inclusions which enter quite easily into castings teemed normally. Spongy draws occur mainly in the upper portions that are in direct vertical communication with the runner, and if a casting is subjected to a hydraulic test they leak at this position.

In the boss of a wheel, for instance, such gassy draws accumulate, but are later brought to the periphery by the metal which passes through the

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arm of the wheel. Only a very small part of the inclusions escape by way of the riser, the rest is found against the wall of the boss of the wheel, causing a defective casting.

An ingenious method for reducing these draws was devised by Mons. Ronceray. This consists of a block of refractory material, incorporating a syphon channel. This block is fitted at the rear of the tap hole of the cupola, and forces the metal to pass through the channel and rise for about 250 millimetres, leaving the furnace in the form of a continuous jet through a channel arranged in connection with the syphon channel itself. Another lower orifice is for the purpose of tapping out at any desired time the iron that has accumulated below the syphon spout. From the upper hole the metal leaves in a better condition than when it is extracted from below. The arrangement has also the advantage that it maintains the charges in their correct position, and also adequately regulates the position of the slag. The absorption of the silicious and sulphurous gases remains however unchanged.

Action of Filter Grates.

From what has been shown it follows that the condition of any casting depends very much upon the conditions of pouring, which can be regarded as a distribution station. The best means for separating the gases from the metal is to break this up away from contact with the atmosphere before passing it into the mould. With this object in view, the author has devised four types of filter grates, adapted to the most diverse castings. One type is designed to supply a good flow of well-filtered metal, so as to avoid ingotism at distant points of a casting, whether cast in chills or ingot moulds, and at the same time control the heat distribution in such castings, the mass of which points to a speeding up of the cooling.

Large and Small Risers.

According to the old school of thought, the scope of the small risers is to aid the evacuation of the gases by eliminating these together with a portion of the metal, which feeds back and replaces them. With the large risers, foundrymen expect to consolidate the metal by gravitation, without giving any consideration to the difference that exists between an inert liquid and an active fluid metal. On an inert liquid, hermetically sealed, a column of the same liquid undoubtedly exercises a pressure in proportion to its height; but with a liquid metal, that is, a material having atomic energy which maintains the mobility of the heat units, until the end of the fluid range, the case is somewhat different. If the large risers are cold before the mass, they are quite useless; if they are, however, of such size as to remain as hot as the mass, the exchange of calories is then equalised. The same kinetic theory shows that with the rising of the temperature, the velocity of the movement of the molecules increases. The auto-movement of the atoms that do not find themselves in the centre of gravity of the molecule renders the structure of the molecule less intimate and reacts in an opposite manner to the affinity; with the increase of the temperature the centrifugal energy of the atomic movement becomes equal or superior to the affinity, and the molecule is broken up. The sum of the active forces of the thermal movements is then constant for every temperature. For all this, there is never a period in which the metal in the fluid state can be benefited by the static pressure, but even if this were possible, the large riser itself would negative the effect, as the pressure would disperse. This is very easily demonstrated by comparing the structure of the metal in the lowest portion of the casting with that of its own large riser, if of the same section. If the riser is of a thicker section than the casting to which it is attached, then it would be the casting that would suffer from the large riser prolonging its action in that place, absorbing a portion of the fluid to be associated with the casting, which would be more porous than elsewhere. Large risers are not only a useless waste of material, but are of a potential danger as they allow the benefit of the auto-pressure to disperse that would be otherwise concentrated within the mass, if the phenomenon of expansion that precedes the contraction could be fully utilised. Worse still, large risers act as conduits for the admission of air, the avoidance of which is important.

Influence of Atmospheric Air.

The volume of air that remains imprisoned in the mould is small in comparison with that which can enter on account of the apertures of the large and small risers and even from the pouring method described if the area of the filter grates exceeds a definite area. If it is presumed that because of the absence of large runner and riser apertures, no more air can be introduced beyond that imprisoned in the mould, what will happen? Whatever the volume of air that is enclosed in the mould, this will be always proportional to that of the metal that will have to fill it, and as the smallest proportion of metal is sufficient for assimilating the small quantity of oxygen imprisoned, only the nitrogen will remain, and which, because of the inevitable rarefaction taking place, will be localised at the top of the mould. The incoming metal has the power to expand and compress it without being harmed itself. In this condition the mould is practically transformed into an empty chamber, or at least a chamber incapable of causing absorption of gas by the metal, so that the metal which is not acted upon by atmospheric pressure can be taken up easily, and be compressed, also because it cannot be acted upon by any portion of the extra pressure which comes about from its rapid momentary expansion. This has more influence on the mass than could be brought about by any other cause.

The volume of air in a mould is in the inverse ratio to the pressure it supports. By heating, the volume is increased. If a given quantity of cast iron is poured into an open mould, represented, for instance, by a plate one metre square, the metal contained will support an atmospheric pressure equal to 22,726 lbs. This pressure does not prevent the escape of the gases, but the cells thus left empty are immediately re-filled with air, which, on being expanded, remains tenaceously *in situ*, opposing itself to the return of the metal. When the plate is cold, it is perforated over its surface. In a closed mould, furnished with vents and large risers, the defect will be proportional to the quantity of air that it was not possible to evacuate. The truth is that the gases (which are in most cases the result of the transference of air) try to escape through the apertures, but are prevented by the greater pressure of the atmosphere. The metal causing the rarefaction of the interior of the mould facilitates the penetration of new air, and in this way is established a continuous circulation, that only stops when the mould has been filled, so that the volume of the air that oxidises the metal can sometimes multiply itself, and reaches quite serious dimensions. It has been observed that in a mould of 20 cub. centimetres capacity, fed by a runner of 20 × 10 millimetres, and having only one large riser of 15 millimetres dia., the air could be renewed fourteen times.

Such inconveniences are still more serious with moulds having projections, or of convex or spherical shape, or moulds without any flat surfaces, against which the auto-pressure is unable to compress the air which cannot be expelled.

The best demonstration of what can be effected by atmospheric air on a mass of metal is offered by the sphere. Cannon ball foundries, at the time when large use was made of spherical projectiles, cast them in rotating metal moulds in order to eliminate air bubbles. Before the introduction of the modern process of filtration, the author had frequent occasion to cast spheres for speed governors, and had great difficulty in obtaining them free from defects; and it was this work which provided the key to later success. The more the large riser was increased the worse became the results obtained, and this brought about its gradual suppression. He also reduced to a minimum the speed of pouring, and thus obtained dense and well-balanced spheres.

In order to confirm the result of this experiment, several other spheres of 20 centimetres dia. (about 64 lbs.) were cast, with large risers of varying diameter. As a result, it was found that the

larger the riser the greater the defects. The explanation of this phenomenon must usually be found in the direction of the incorporation of atmospheric air. In fact the greater the facilities allowed for the escape of air, the greater is the chance of its intervention; the internal rarefaction is more rapid and the greater the "empty-chamber" to be re-occupied. When the metal reaches the end of the underside of the cope, it often happens that bubbles of air in the form of a circle remain imprisoned, corresponding with the position of the large riser, and the size of this circle varies with the size of the riser. This air, through being strongly expanded, is the cause of very marked depression, but one not generally appreciated.

In massive blocks, it is indispensable that the mould walls be quite dry in order to be in a position to oppose by their rigidity the stress set up by the liquid metal. Wet walls give way, causing leakage, not through aspiration, but through a general increase in surface.

It is equally important not to close moulds whilst the sand is still warm. If this is done, water vapour is invariably developed, causing two types of defect. If the vapour is transformed into dry steam, it causes a depression at the surface of the bath, whilst, if it is dissociated and re-combines, explosions follow that violently agitate the metal and cause it to imprison air.

Small risers are permissible where weak sections make it impossible to take advantage of the benefits derived from expansion, because of the rapid chilling of the metal. They are also necessary in every constricted position, and especially in places near to the runner, as in the case of wheel bosses, for aiding the expulsion of the gas that is contained in the runner itself. But in any case they must not exceed 9 millimetres dia. in order to allow the gas to escape under a pressure, if not superior, at least equal to that of the atmosphere.

Distribution of the Useful Heat.

Of great importance for the logical distribution of the heat in any casting is the correct choice of the position for the placing of the runner and its branches. It is usual to place them in the easiest position, without considering the influence that can exercise on the molten mass by means of a more rational distribution of the available heat units. In fixing the position of the runners, there must be taken into account the following:—First of all, the metal maintains itself hotter in the direct vicinity of the runner, as here it is constantly being renewed. Moreover, if the runners are placed above or against a section which is stronger in comparison with another, the temperature is reinforced and prolonged in a position where it is already out of proportion with regard to the weaker portion. In this way the moulder goes against the law of the equilibrium of the contraction, and encourages the molecular looseness where it can be expected to be excessive.

When casting a block, if it is poured from the top or in the centre, the central seat of the generation of heat is rendered more active in comparison than those nearer to the periphery. When the metal is distributed by means of small canals equally distributed around the periphery, this helps towards reinforcing the heat at places more distant from the centre. The equilibrium set up, if not actually balanced, is in all cases much better.

This principle holds good for locomotive wheels. In such wheels the maximum concentration of heat is at the base of the bosses and in the counterpoise. Canalising the metal from the boss helps to keep up the available heat until the end, where they are already in excess so far as the position of the weak portion of the rim is concerned. It sets up a loose texture in the heavy sections and increases the tendency to lower the strength of the rim. By applying a certain type of filter grate directly above the relative smaller section of the rim or tyre of the wheel, the conditions are totally changed. In the boss and counterpoise, the cast iron is fed in much colder, as during its passage it loses some of its heat. The rim benefits as a consequence of the continual renewal of metal. A better equilibrium is set up, which increases the strength of the weak portion of the rim, and, generally speaking, makes for a much better casting.

Bottom pouring has the advantage of allowing the impurities present—when the cast iron is not filtered—to float. But the use of this form of pouring means the discarding of a large, heavy riser. The large riser, however, induces a strong, continuous current of air. This sets up a definite action on the surface of the metal, making the part actually in the large riser decidedly pasty. Besides this, because of the renewal of the metal being carried out at the bottom, and not at the top, the condition of the mass with respect to the concentration of the heat becomes inverted, and therefore out of equilibrium with regard to the final need for adding feeding metal.

Experience has shown the need for pumping. This has for its object the procuring of good, solid metal in the heavier sections of a casting. It is accomplished by pushing the metal with an iron rod through a large riser, which is nearly inert because of its pasty condition. But the pumping rod, while alternating with its to and fro movement through a large riser, collects the pasty metal upon itself, forming an agglomeration, which creates a small metal well of pasty metal. Fresh metal is poured when the rod is at last withdrawn, but before the metal can re-occupy the cell, air has arrived there, and does not allow itself to be dislodged, especially as it has expanded. If the rod during its work has reached beyond the riser, then the spongy place is centred within the casting, while if it has remained in the riser, then this defect will be found there.

When making rolls good results can be obtained by casting them directly against their necks. The neck is nearly doubled in height, but remains totally enclosed. A filter grate, of predetermined size according to the weight of the roll, is utilised. The metal that makes its way through the filter falls vertically, filling first the lower neck and then the rest of the mould. The filling is very rapid, and does not allow sufficient time for the sprays to oxidise. The upper elongated neck, which is the last to be filled, institutes much better conditions than is possible with any large riser, and can feed itself much better than is the case with the hypothetical descent of metal, associated with pumping. Besides this, owing to the complete insulation from the atmosphere, no oxidation can take place in the metal, and all the advantages to be gained from expansion can freely take place within the mass, which undoubtedly makes for compactness. The roll is thus more homogeneous, and its necks are stronger.

There are, however, exceptions. Within an exceptionally large mass, in which the latent heat is considerable, the sum of the calories is so large that it is indispensable to adopt special measures for reducing the consequences. A well-devised distribution of runners in the portions most distant from the centre of the concentration of the heat is always a very good help, but this single precaution is insufficient for the special case. A vigorous ally is in this instance the mechanical reduction of heat available. Powerful effects are obtained through employing special refractory plugs, which are made to compress the metal through large covered risers by means of a simple lever arrangement. In some cases an addition of antimony is very effective. The proportion of this should not, however, surpass 30 per cent., or it will harden the metal excessively.

Any casting of cylindrical form, however massive, turns out quite solid, even when cast horizontally, if poured with filtered cast iron, and protected against the action of the atmosphere. In this way the employment of the costly large risers is eliminated, as well as the time spent on pumping. Before the discovery of the combined actions—"filtration and elimination of air"—it was not possible to cast such castings horizontally owing to the agglomeration of impurities which took place, and also to the sinking of the metal taking place along the top of the cylinder, set up by the large amount of air bubbles present. Such a casting resembles an enormous levelling instrument, within which one or more strong air bubbles take up a large space within the metal. If the level of the mould is kept slightly inclined, and filtered metal is introduced from the bottom, it is clear that the volume of air imprisoned in the mould

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will be pushed by the metal itself towards the opposite elevated extremity, where a covered collector is arranged to receive it.

Origin of the Blow Holes.

Blow holes are for the greater part brought about by:—

(1) Excessive ramming of the mould, especially the mould face;

(2) Insufficient venting of the cores, or too close a texture. If a core is completely surrounded by metal, or its shape does not allow for the escape of its gases, care must be taken to limit as much as possible the thickness of the sand, filling it internally with small grains of coke. Rodding should be avoided, as the wires when subject to the high temperature expand and bend, causing cracks and a localised escape of gas;

(3) Gases passing through the cracks in the cores or moulds;

(4) Gases developed from the cores which have shed their graphitic facing and become porous;

(5) Gases arising from the filling of cracks with oil and graphite; and

(6) Development of water vapour within a mould which has been closed whilst the sand was still warm.

The gases developed through the cracks or through the porosity of the cores definitively contain hydrogen, and if this gas does not come in contact with the oxygen of the air, it is without effect, as it cannot form explosive mixtures. By eliminating all air currents the combination can be stopped, so avoiding the formation of bubbles of occluded gas.

Blow holes arising from steam can be avoided by refusing to close a mould whilst the sand is still warm. This precaution is indispensable, especially for moulds for large masses. The closing of a mould with warm sand is always harmful, even with very small sections; if such moulds contain chaplets the steam will condense on them.

The contact of the metal with an excessively moist or compact mould face sets up, primarily, a repulsion of the metal. The sand bared through the momentary flying off of the metal having been burnt, it has no longer the strength to resist the pressure of the gases that attempt to escape through its pores, and in this way the first disintegration takes place, and the gases then make their way through the breach thus made, passing very quickly into the mould, and projecting the metal from the openings of the risers if the mould is provided with them. The first breach is quickly followed by either an increase in size, or by other breaches, because of the turbulent conditions set up.

It is not difficult to understand, that if there are no large runners or risers through which the metal can be projected, it remains in its place, and the action is stopped. Supposing, however, that a first impact causes the formation of some air holes; these are always closed up because of the expansion properties of the metal, when due to the absence of openings it is not deprived of the means to utilise this phenomenon.

CONCLUSION.

The application of the process gives unhoped for results, and has the merit of simplicity. In fact it only requires the careful observance of two principles: Filtering the metal and isolating the mould from the atmosphere.

The author, whilst indicating the general instructions that preface his book on this subject, hopes to co-operate in the improvement of making castings in general. Certainly, much road still remains to be covered before completely dispersing the clouds that envelope certain metallurgical phenomena.

The author will be particularly happy if he has succeeded in convincing Mr. Smalley that the spongy place defect encountered in the cylindrical block, cast with a large riser, is to be ascribed to enclosed air.

The appearance of the cavity found in the other cylinder made without risers and with a filter grate still remains to be explained.

The author is inclined to believe that the sponginess encountered in this second cylinder can be attributed to two contributory causes. If, as is stated in the French translation of Mr. Smalley's Paper, the mould was closed with sand warmed to a temperature of about 97 deg. C., it is without doubt that much water vapour would be developed before the arrival of the metal. In this case, besides the volume of the air imprisoned, there had to be overcome an energetic opposition, caused by the combination of air and steam, and this, if pushed upwards by sufficient pressure, could resolve itself into producing a slight heaping or piling up against the molten metal. Here the question arises: Why did the pressing action fail? Evidently Mr. Smalley, by casting that cylinder with a grate reduced to the lowest dimensions, aimed at ascertaining the limit of its potentialities. But in so doing he set up an inert condition in the metal by removing from it the expansion period, and also helped along the phenomenon of the contraction. The slowness, with which the metal expands itself, corresponds with the cooling, say, at the periphery of the cylinder, while the new metal revives the temperature at its centre. This condition brought about the absence of means for the necessary reaction for compressing the mass and forcing the gas to flatten at the top. No surprise, therefore, need be occasioned if the steam was trapped and absorbed by the vortex of the central part of the cylinder, owing to the higher temperature.

According to the author, for such a casting there should have been five delivery points of 6 mms. each, and not but one alone of 6.3 mm.

Foundry Conditions in the Irish Free State.

Mr. H. Gratton, writing in a recent issue of the "Irish Builder and Engineer" on this subject, points out that the rate for moulders is £4 8s. for a 48-hour week in Cork, which is 1½d. per hour greater than Dublin, and much higher than the British rate. He states that Irish-owned engineering firms are in a very backward condition, and are paying vastly higher wages than their British competitors. He submits that no conclusion can be reached until the following points have been studied:—

(1) The castings required for the Irish market; (2) the production of metal of consistent quality, and suited to the work in hand, making use of as large a quantity of iron and steel scrap as possible. This will involve chemical control, and such control is notoriously not applied; (3) having in view the quantity requirements of the country, the practicability of moulding machines must be considered; and (4) the question of production cost, per article, should be studied in every detail, and allowance made for effect of wage rates, cost of materials, and possible economies.

After deploring the non-existence of an organisation akin to our National Physical Laboratory, the author refers to the inadequate use made of the iron and brass foundries at the College of Science in Merrion Street, Dublin, which is admirably adapted for the carrying out of experimental work. We would remind Mr. Gratton that there exists the British Cast-iron Research Association, which is open equally to founders of the Irish Free State as it is to all countries entering into the British Commonwealth of Nations. Irish Free State foundry conditions are, after all, not so very far removed from those obtaining in country districts in England, and they can be assured that they will be catered for adequately. Then, too, Irish foundrymen of any category are equally eligible for membership of the Institute of British Foundrymen, which includes in its membership list French, Italians, Spaniards, Americans, Indians, Canadians, Australians, South Africans, Egyptians and many other nationalities, but there is no representation from any Irish Free State foundry.

Industrial Welfare Work.

Last week-end at the annual conference of the Institute of Industrial Welfare Workers, held at Swanwick, Derbyshire, nearly 100 delegates from British and foreign industrial concerns were present. Mr. A. C. Marshall (Sheffield), in the course of his presidential address, said other countries were looking to Great Britain for advice on industrial welfare conditions.

Evolution of the Iron Trade and its Relation to Foundry Practice.*

By J. I. Coleman, A.M.I.Brit.F.

(*Abstract.*)

The manufacture of iron was carried on in many districts of the kingdom from a very early period. The Romans no more neglected this than they overlooked other sources of power; for abundant evidence is still extant to show that they discovered the localities where iron ore existed, although, because of their limited resources of working at command, they chiefly, if not wholly, availed themselves of the deposits which cropped out actually at the surface, or were found at very easily reached distances from the surface of the soil.

At Gloucester, so early as the date of the Norman invasion, the manufacture of iron was carried on to what would then be called a great extent.

Sussex was the chief seat of the iron manufacture of the early times of this country. Fuller, to whose quaint history of the Worthies of England, written so early as 1662, modern historians owe so much, says "great was the quantity of iron made in this county." The fuel used then was charcoal. In course of time the difficulty of obtaining supplies of charcoal in this country had brought the manufacture of iron to such a point that its production almost ceased; so scarce had fuel become in the reign of Edward III that all exportation of it was prohibited under severe penalties. For long we were practically dependent upon the densely wooded countries of Northern Europe, who not only were fortunate in the possession of an unlimited source of charcoal supply, were equally so in having mines of the finest ores.

The iron made in those early days of European civilisation was of wrought iron type. This was of the finest quality, approaching very near the quality now designated "mild" steel, and was carried on in this country up to the reign of Elizabeth. "Pig-iron" was very likely introduced early in her reign, and probably carried on for some time, because we find the first recorded statement concerning the art tells us of cast iron used as a substitute for bronze in the manufacture of ordnance. The primary cause of the discovery of new processes or appliances has been one or other of the many requirements of war. Since the great Exhibition of 1857 there has been a remarkable and continuous development in the manufacture of all types of materials of war.

Advent of Coal.

The difficulties arising from the want of charcoal would be easily overcome by the use of the common coal. But plentiful as coal now is, and comparatively easy as it is to procure it from the mines, things were not always so. It was some time before it became known that coal existed in such enormous quantities, and had it not been that precisely at the time wanted the steam engine came to the aid of the coal-pit proprietors the supply would have utterly failed.

About the end of the 13th century coal was obtained in fairly large quantities from the pits at Newcastle-on-Tyne, the earliest from which port large bulk was exported to what were then called the "low countries"—now Belgium and Holland. This export was carried on principally to supply the iron workers with fuel for the production of iron, wood being over a large area of this part of the Continent as scarce as it was with us. One would think that this fact of its being so employed would have naturally struck the iron makers of this country as one valuable for their trade purposes as it was for the makers of the Continent. One would have supposed that this would be the inevitable result of the circumstances then existing, but British iron makers then not only refused to avail themselves of the help out of their difficulty in the matter of a non-supply of charcoal, which coal was thus proved by other makers to give them, but they went further, and maintained that coal could *not* be used for iron making in any way. In 1612, however, the first recorded trial of coal as a fuel for smelting or reduction of iron in the trade or branch of cast-iron or pig-iron making was made by Simon Sturtevant, who may have had some practical connection with Continental iron making in which coal was the fuel used. A patent was granted to him for 31 years, which appears to be the extent of monopoly then granted, and by its terms he was bound to publish an account of his invention. This he did in a work entitled "Metallica," but, as one authority has said, somewhat after the fashion of the time, "when those who knew the 'arts' made of them a mystery," this gave no practical information bearing on the subject. The patent of Sturtevant was rendered void, as he seemed really to have had no more practical knowledge of the subject than his book had information respecting it.

In or about the year 1619 Dudley was granted a patent for 31 years for the use of coal as a fuel for reducing iron ores and running them off as cast or pig-iron. This was the year, however, in which Dudley left Oxford, where, at the age of 20, he was then studying to assist in the management of his father's iron works, situated at Ponsuet, in Worcestershire. It was here that Dudley conceived the idea of making pit coal useful for iron-reducing purposes, and his attempts to utilise it succeeded beyond his highest hopes.

In the early days of the iron trade charcoal was invariably used. Whether this was what suggested the previous treatment of coal, or whether the first trials were made with raw coal, it is certain that from almost the very first coal was used in the iron furnace in the form of coke, in which state it is now standard for blast furnace practice.

Successful beyond a doubt in his system of reducing iron by means of coal, Dudley had to contend with a power which even he, with all his known skill and courage, could not cope, and which at last converted his success into a miserable loss, and caused him to end his days a ruined and broken-hearted man.

The 18th century saw a gradual improvement in the production of pig-iron. In the year 1740 the total production of iron in the kingdom reached the miserable amount of 17,350 tons. Such was the result of the 124 years during which Dudley's invention passed out of practical existence. The process was at last re-introduced in times not quite so evil. In a little under half a century the make of iron had risen to four times nearly, or to 61,300 tons, which was the production in 1788. The process by this time began to exercise its full power, for at the end of the next 18 years the make for the year 1806 was no fewer than 250,000 tons. In 1827 it had got over the half-million—654,000. In 1845 more than the million—1,250,000. And now this may be safely set down as being multiplied eight times, for in 1913 the making of pig-iron reached the total of 10,260,315 tons. Then came a rapid decline, the output for 1919 being only 7,398,000 tons. This was due to the war. If we accept the suggestion of Sir R. Hadfield "that the production of iron serves as an index of the state of civilisation," then iron is an essential agent of a higher civilisation. On September 30, 1923, the total number of blast furnaces built were 485, and only 189 were in blast at the same date.

Cupola Practice.

Successful founding depends more on efficient cupola practice than is supposed. It is surprising the many crude and tumbled-down furnaces which exist and which give fairly good results. There is no branch of iron founding better worth care-

* A Paper read before the Burnley Section of the Institute of British Foundrymen, Mr. G. Barnes presiding.

ful study than cupola. Many founders are looking anywhere but in the right direction for the causes of defective or waster castings. The principal causes of bad melting are wrong quantity and wrong delivery of blast, and faulty arrangement of the charge in the furnace. There must be some common ground in cupola practice by which a founder should be able to determine and deliver hot, fluid metal from the cupola. The determining factor must be that a cupola of given interior diameter should be worked to deliver a certain quantity of iron within a given time which under no circumstances should be altered. The reason for this is, that for all intents and purposes there is really only one correct system of producing iron of the correct quality from one particular cupola, *i.e.*, one volume and velocity of blast and one arrangement and weight of fuel and iron to bring the iron charges directly into the melting zone at the correct time, and under the correct conditions. Granted the right quantity of air delivered into the wind box and the tuyeres so arranged as to ensure its passing into the cupola at the right velocity, the scheduled quantity of iron should come down. It it does not come down, then the founder must look for the fault in the weight and arrangement of his charges, and it will be necessary to experiment until he finds the necessary height of coke bed and alternate charges of fuel and iron, which will bring the latter always exactly into that zone in the furnace in which it will be melted most quickly and advantageously. Investigation has fairly established the constancy of one factor, *i.e.*, the volume of air required to promote the combustion necessary to melt properly one ton of iron (30,000 to 35,000 cub. ft. of air), and this gives the founder at any rate one definite basis upon which to work.

It is important that the founder should know exactly what volume of air the blower is delivering, and that the arrangements should be such that, when the blower is delivering the correct quantity of air, that air is passing freely into his furnace.

Necessity for Good Material.

It may be safely said that a cupola will deliver what is put into it, if intelligently used. The graded mixtures for variety of work in progress must be determined not by rule of thumb, but by a careful analysis of the value of each iron in each mixture to secure a given result. This is essential in a large works, where it is possible to analyse coke and pig as delivered into the works. As for the small iron founder, it is still possible for him to take certain tests and to consult a metallurgist.

Sand.

This subject has merited attention by expert foundrymen both at home and abroad. America possesses rich deposits of bonded sand, and for the brass foundry and light iron castings the sand found in Albany, U.S.A., is quite good. We possess in this country equally good sand, and in close proximity—Lancashire, Yorkshire and the Midlands. After a careful study of sands for moulding purposes, and securing a good skin on castings, the author's practice is to grade sand-mixtures similarly to iron mixtures, each grade possessing bond, porosity and moisture content suitable for each class of work in progress.

Facing sand is divided into strong, medium and light casting mixtures. The North-West Coast sea sands, mixed with oil, give excellent results, as to withstanding pressure and free stripping properties. For light work, and medium work in values, pumps and air compressors, cylinders, they are indispensable. Sand is looked upon as a very common element in the universe, but to an alert foundryman its value becomes everyday more important.

Mechanical Appliances.

This development has received great impetus during the War, owing to vast requirements which necessitated quicker and more accurate production. The slow movement of the old style of cranes used principally for heavy and medium class work, are fast disappearing, being replaced by electric cranes. The result is the better and speedier handling of material. There is a real relationship between the speed of a crane and the speed and alertness of the men working in the foundry. In sand-mixing there is a marked change from the old method of treading the sand with the feet, as still seen in many jobbing foundries. No modern firm can afford to disregard appliances for the handling and mixing of sands, because of its effect on the quality of the finished castings.

Good mixing machines, sand mills, electric or compressed-air sand-riddles, are of vital importance in the foundry. The uses to which compressed air are put in the foundry are numerous :—mould drying, mould cleaning, jar-ramming for light and heavy work, etc.

The introduction of moulding machines into the foundry requires careful thought, especially so where there are a great variety of existing plates and constant change. After careful consideration the author's firm decided to install a battery of Osborne jolt press machines, which are quite efficient and suitable for the class of work turned out.

The chief points in any machine, however, are speed, ease and fewness of operations. Machine-made castings are more uniform and true to pattern, and are to be commended on those grounds alone.

Gating and Running of Moulds.

The value of a runner determines the quality of a casting so far as freedom from scabs, over-strain from running too fast and dirt. Running too slowly produces cold sheets and hardness. These are problems in which the theorist must allow the experienced practical foundryman to take precedence. It requires both experience and sound judgment, for many difficulties are encountered.

Having given considerable thought to this subject, the author has come to the conclusion that the safest and wisest method after determining the best results is to record the system of runner or runners for each particular casting, particularly the loose runners, as used on bedplates, frames, bosses, flywheels, cylinders, machine tools, fixings for mill gearing, and the like. The results accruing from this method will repay anyone for the time and thought expended.

There is now more care bestowed upon safety, ventilation, and good working conditions. There is a more intelligent interest on the part of the foundryman in relation to his work. With all the machinery which may be placed in the foundry, the craftsman will have his place, and it will be a very important one.

DISCUSSION.

Mr. J. Hogg said the author had given an interesting resumé of the progress made by the iron trade, particularly during the last hundred years, and none could fail to be impressed by the difficulties which had to be overcome in the early days. The average Englishman appeared to regard it as his prerogative to depreciate the efforts of his own people, and while much was heard about the progress made in other countries, such as Belgium and Germany, and the skill of the workers there, the fact was overlooked that quite as much could be said for this country.

Coming to the practical side of the Paper he agreed with Mr. Coleman as to the importance of the cupola operations. Intelligent co-operation by the men with the foreman was essential. However good his methods might be he was always liable to be let down by the faults of subordinates. The necessity of carrying out instructions exactly was not always realised. Not only must the correct mixture be put in the cupola; other details must be correct. For instance, the volume of air had a material influence. He had heard a foundryman say that he could reduce the strength of test bars from 18 to 12 tons merely by altering the force of the blast.

Mr. Pell said the present-day moulder was equal in skill to his predecessors, but there was room for improvement, especially in the knowledge of the theoretical side. If they studied that aspect moulders would not be blamed for many things which were now laid to their charge.

Mr. Seed asked whether Mr. Coleman could explain the cause of sponginess or kish in a wheel casting, and suggest a remedy for it. In this casting it was exceedingly difficult to get the arm

quite clean without being spongy at a particular point between the outer rim and the boss.

Mr. Coleman said that in large rope pulleys and flywheels he had found that no matter the type of feeding it was spongy between the arm and the inner rim. For tuppet wheels, drilling was advisable. The curved arm was free from sponginess.

Mr. Hogg said it was difficult for the foundryman to get a design altered. Any trouble of that kind could be remedied by the use of denseners.

Mr. Pell agreed that denseners would do good, but if one had to chill these places the same amount of output could not be expected. Experience showed that whilst one consignment of pig caused no trouble another consignment, from which the foundryman expected similar results, disappointed him. They did not all have the advantage of being able to have samples of pig-iron and other materials analysed so as to make sure that they were getting what was approximately the same as the material previously used and on which their experience was based.

Mr. Seed put the case of two shanks of metal. The first became stiff very quickly, while the other remained fluid much longer. The former metal was as rough as it possibly could be, and presented an appearance of gravel, or plumbago, or blacking, had been thrown on.

Mr. Coleman asked if metal had been run in the first shank from the furnace at the first tap? It would not be as hot as the second shank. The metal would not have quite the same qualities.

Mr. Seed said they had run out about 6 or 7 cwt. of metal before they took the first shank which became kishy.

The Chairman suggested that this trouble sometimes arose from bad charging. If a mixture of scrap and pig-iron was being used the mixing might not be properly done. If the scrap was put in first it might be melted much sooner than the pig. He tried to avoid that by putting in the pig first and then following with the scrap, but others might have a different practice.

Mr. Pell said it was his practice, especially with textile castings, to mix the scrap and pig together.

Mr. Greenwood said different brands did not always blend together as they were expected to do. That sort of thing might occur at any time, and then, not having what they required, the material had to be used up into such things as grate bars. At his own place the practice was as soon as the blast was put on they stopped up the hole and then let it run, until there was 4 or 5 cwt. in the furnace bottom.

Mr. Coleman said that course was extensively followed in Lancashire. Mr. Pell adopted another method. He himself used both, but preferred the former.

Mr. Pell said his experience was that if they allowed a quantity of metal to collect in the receiver it would be mixed. The pig and scrap would melt together so that it all mixed.

A vote of thanks to Mr. Coleman concluded the discussion.

Book Review.

Factory Costing, by H. H. Emsley, B.Sc. Published by Messrs. Constable & Company, Limited, 10 and 12, Orange Street, Leicester Square, London, W.C.2. Price 7s.

This book is the result of requests made to the author to present in book form a course of lectures on costing given to students who are to become engineers, scientific instrument makers and opthalmic opticians. As can be anticipated, it is of the text-book variety and loses some of its value as a works reference book. A fundamental error from the foundryman's point of view appears in the second chapter, as he teaches his students to buy iron castings on a per cwt. basis, the price decreasing with the weight. In the interests of a great industry, it is to be hoped that the author in a future edition will state that the price of castings will vary with their complexity and not with their weight. We fail to see the object of the inclusion of a page from the catalogue of a prominent glass manufacturer dated January, 1920. Books as far as possible should not only give the latest data, but preferably of a lasting type.

Surveyed as a whole, we find his chapter on material distinctly disappointing, apart from the fact that its technical reception is stressed.

The chapter on "labour" is much better, but one receives the impression that a few—not all—systems of payment are put forward for selection by the management. For a work of this character we suggest that as selection is not usually a matter of choice, the author would have done better to emphasise the collection, analysis and easy expression of the figures returnable by a system of payment. For instance, the "fellowship" system, which the author deals with under the caption of "collective bonus system," might usefully have been dealt with from the viewpoint of the title of the book, because one of its common failures is the inability of the costing department to state the amount of bonus payable within such a time as to allow the recipients to co-relate their efforts with the reward received.

The book contains some 250 pages, is divided into 12 chapters and 41 diagrams. Chapter 10, which deals with the actual cost of production of 100 bull's-eye condensers, is quite good, but we feel there are several cards too many. If the proposition was the machining of built-up chain or the making of an electric light bulb, the number of forms shown would be justified. We congratulate the author on his last chapter, which deals with costing in the small factory or workshop. Whilst it is a little platitudinous, it contains many truths worth while studying by small foundry owners. Now the case outlined in Chapter 10—the 100 bull's-eye condensers—is not too big for the "small man," and it would have been interesting if the author had indicated precisely the amount of costing system he should employ so as to ensure (*a*) a reasonable profit for himself and (*b*) the avoidance of a cut-throat selling price which spoils the market for the trade generally. We commend the book to our readers, especially the small foundry owner.

Contracts Open.

Bangkok, December 31.—Accessories for goods rolling stock B.E. 2,467 (laminated springs, axleboxes and axle guards), for the Siam State Railways. Messrs. C. P. Sandberg, 40, Grosvenor Gardens, London, S.W.1. (Fee, £1.)

Cairo (Egypt), October 25.—The Ministry of Finance, Cairo, Egypt, require 75 iron safes in accordance with specification. Alternative quotations are desired, however, for 100 safes. The Department of Overseas Trade, 35, Old Queen Street, London, S.W.1. Ref. A. X. 1321.

Blyth, Northumberland, October 15.—Supply and erection of steelwork, ironwork, etc., for two sets of fixed gravity spouts and hoppers, telescopic hanging spouts, etc., for the London & North-Eastern Railway Company. Mr. C. F. Bengough, chief engineer for the North-Eastern Area, Forth Banks, Newcastle-on-Tyne.

Durban, October 10.—261 double-socketed sluice valves, for the Corporation of Durban, Natal. The Department of Overseas Trade.

London, S.W., October 10-24-November 21.—(1) Metals; (2) Sheffield tools, etc.; (3) copper tubes, brass sheets, etc.; (4) Yorkshire iron; (5) locomotive boilers; (6) points and crossings, etc.; (7) mild-steel bars, sections, etc.; for the South Indian Railway Company. The Company's Offices, 91, Petty France, Westminster, S.W.1.

London, S.E., October 9.—Joists, for the Director-General, India Store Department, Branch No. 14, Belvedere Road, Lambeth, S.E.1.

Northwich, October 6.—Supply of about 650 tons of 10-in., 9-in. and 6-in. cast-iron pipes and specials, for the Northwich U.D.C. Mr. W. M. Beckett, 10, Throgmorton Avenue, London, E.C.2. (Fee, £3 3s., returnable.)

Shanghai, December 8.—The Kiaochow Tsinan Railway require deck plate girders and through plate girders for bridges and one through truss bridge.

Edinburgh, October 13.—Two water-tube boilers, 65,000 to 80,000 lbs. per hour capacity, complete with economisers, chimney fans and pulverised fuel plant, etc., for the Corporation. Mr. E. Seddon, interim engineer and manager, Dewar Place, Edinburgh. (Fee, £3 3s., returnable.)

Newcastle, N.S.W., November 25.—The Caledonian Collieries, Limited, Newcastle, New South Wales, Australia, requires supply and erection of turbo-alternators, condensers, pumps, boilers, pipework, superheaters, chimney, fans, switchboards, transformers, etc. Howard Smith, Limited, 33, Cornhill, London, E.C.3. (Fee, £1 1s., returnable.)

XUM

The Analysis of Grey Iron Foundry Alloys.—VII.

By H. H. S.

THE ESTIMATION OF PHOSPHORUS.

Two methods for the determination of this element will be described: both are "phospho-molybdate" methods in principle, that is to say that in both methods the phosphorus is precipitated as the yellow compound ammonium-phospho-molybdate, but one is finished off gravimetrically and the other volumetrically.

The Gravimetric Method.

This method is not recommended for adapting to routine work, as the determination requires too much time and attention to complete, for ordinary work; it is, however, apart from the time factor, a very satisfactory and accurate process, suitable for determining the amount of phosphorus in an iron which is to be used for a standard or for special check analysis, such as may arise from or for specification work.

Solutions Required.

Ammonium Molybdate.—Dissolve 100 gr. of pure, ground, molybdic acid in a mixture of 250 c.c. H_2O, and 170 c.c. NH_4OH, stir well and warm slightly to aid solution: then pour the whole into 1,250 c.c. of 1.2 sp. gr. HNO_3, which should be contained in a Winchester quart bottle; shake well, and allow to stand, if possible, for a few days, before using. On standing, a yellow precipitate settles out, it is therefore necessary in the gravimetric method to *filter* off one or two days' supply through a close textured filter paper. This not only prevents contamination of the phosphorus precipitate with the yellow precipitate referred to above, but also ensures that the solution is free from possible insoluble impurities such as silica, dirt, etc., all of which would obviously effect the accuracy of the estimation. It is not necessary to filter the molybdate solution when the volumetric method is employed, the clear liquid being simply *decanted* off. The solution should be made up in the order given, if the nitric acid (HNO_3) is poured into the ammonium molybdate solution, a dense white precipitate—oxide of molybdenum—is formed, which spoils the solution; but dissolving the molybdic acid in the NH_4OH and proceeding as described no trouble will be encountered.

1 *per cent.* KNO_3.—The salt should give a neutral reaction to litmus, when in solution.

Method Used.

Weigh into an evaporating dish or casserole, as used in the determination of silicon, 0.50 gramme of the sample, cover with a clock glass, and then add down the lip, 25 c.c. of 1.2 sp. gr. HNO_3, carefully evaporate to dryness on the hot plate, and bake for 15 minutes, or until no nitrous fumes are evolved: allow the dish to cool, and add 40 c.c. of concentrated HCl, boil down to about 15 c.c., add 25 c.c. H_2O and heat to boiling point. Filter off the silica and graphite residue, through a 12.5 c.m. "40" paper, receiving the filtrate in a 400 c.c. conical flask; the residue should be washed, first once with hot water then once with HCl (1-1); repeat this, then wash once with H_2O finally. It is advantageous to keep the volume of solutions and washings as low as possible, so as to cut down the amount of time required for the next operation, which is to boil down the filtrate to about 10 c.c. After boiling down remove from the plate, add 25 c.c. of hot H_2O, and heat until all the salts have gone into solution, cool in the sink, then add 0.880 (conc.) NH_4OH until the liquid becomes thick and pasty. To the viscous mass add, carefully and while shaking gently, 1.2 sp. gr. HNO_3 until the iron is dissolved, and the solution becomes clear, add 10 c.c. of acid in excess, heat to boiling, allow to stand for three minutes. Add to the solution, while shaking gently, 40 c.c. of the ammonium molybdate, insert a plain rubber bung and shake vigorously for 1 to 2 minutes, remove the bung and wash with H_2O, allow the washings to drip into the flask. Allow the precipitate to settle for at least 20 mins., during which time the precipitate will settle out completely, if the solution is treated as directed.

The object of allowing the solution to stand for three minutes before adding the molybdate is to permit cooling of the liquid to a temperature which ensures rapid precipitation and settling of the phospho-ammonium-molybdate, and eliminates trouble. If the temperature is above 80 deg. C., molybdic acid is precipitated along with the phosphorus; this acid is extremely difficult to wash out, and when the acid is present in any quantity it usually results in scrapping of the tests or incorrect results, or both. The time period given allows the solution to cool down to 75—80 deg. C., and since temperature is of much importance in this method, it is plain that adopting the "three minute standing" operation is a distinct advantage, assuring the correct temperature range without the use of a thermometer, and avoiding precipitation at "guess work," and invariably incorrect temperatures.

To ensure efficiency, expressed in terms of rapidity and accuracy, the importance of standardising every detail of this estimation cannot be over emphasised. When the precipitate has settled, decant off the clear liquid through a weighed Gooch crucible containing a double thin layer of asbestos wool (burnt), which has been washed twice with 1.2 sp. gr. HNO_3 and twice with hot water.

The crucible should be dried at 110 deg. C. in an air oven for 45 mins. before weighing and using.

To the precipitate in the conical flask, add about 20 c.c. of 2.0 per cent. HNO_3, shake, allow to stand; meanwhile wash the asbestos filter once with 2.0 per cent. HNO_3; again decant the clear liquid from the flask and add 20 c.c. 2.0 per cent. KNO_3, wash, filter again with HNO_3, pour off the KNO_3 from the flask through the filter, when it has passed through wash the precipitate into the filter, add about 20 c.c. cold H_2O to the flask, wash the precipitate in the crucible once with KNO_3 and pour the H_2O from the flask on to it. Finally wash well once with H_2O, washing the precipitate on to the asbestos layer, test the last washings for acidity by aid of a piece of *moistened* blue litmus. For a certain practice the above system of washing was found quite sufficient to render the precipitate acid free, and the litmus test was abandoned, with a consequent saving of time especially when a number of estimations were made. The "decanting" method of washing is often ignored by the modern chemist as being too slow, but the writer's experience is that in estimations as just cited, and where there are numerous tests to make of the same or other elements this system not only saves time but invariably saves solutions too.

The crucible is removed from the suction pump and dried at 110 deg. C. for 45 mins. The temperature must not exceed 110 deg. C., or decomposition of the precipitate will take place. The weight of the precipitate multiplied by 1.65 ÷ 0.50 equals per cent. phosphorus (P).

Volumetric Method.

This is similar in principle to the gravimetric process, varying only in details and in the final operation; it is the ideal method for works practice laboratories on account of the rapidity with which one can arrive at the result. The method also leaves nothing to be desired in regard to accuracy, there being no difficulty in securing results accurate to .005 per cent.

The following solutions are required:—Potassium permanganate ($KMnO_4$), 1.5 per cent. solution; ferrous sulphate ($FeSO_4$), 25 per cent. solution, containing 5 c.c. concentrated H_2SO_4 per 500 c.c. solution; ammonium molybdate [$(NH_4)_2$ MoO_4], as used in gravimetric method; HNO_3 $\frac{N}{8}$ solution, made by diluting 16 c.c. of the concentrated HNO_3 (1.42 Sp. G.) to one litre; KOH stock solution, prepared by dissolving 140 grammes of pure KOH sticks in 200 c.c. H_2O, cooled and diluted to two litres; KOH $\frac{N}{8}$ solution, dilute 100 c.c. of stock solution to 1,000 c.c. (the $\frac{N}{8}$ HNO_3 and the $\frac{N}{8}$ KOH are balanced against each

other so that a c.c. of the one will equal or neutralise exactly one c.c. of the other); and phenolphthalein indicating solution, prepared by dissolving 0.20 gramme of the reagent in 100 c.c. of a 50 per cent. alcohol-water solution.

The Estimation.

Weigh 0.50 gr. of the sample into a 150 c.c. tall-form beaker, add 25 c.c. of HNO_3 (1—1), cover with a 3-in. cover glass, and heat gently until the sample is dissolved: boil to free solution from nitrogen oxides. The insoluble residue of graphite and silicon is filtered off through filter paper pulp by the aid of a filter tube, flask and pump; the tube should preferably be of the size recommended in the section of this series which deals with the estimation of graphitic carbon, *i.e.*, 2 in. by 1 in. (diameter). Wash out the beaker once with 2.0 per cent. HNO_3, and pour the acid on to the filter; repeat this, using H_2O. Transfer the filtrate to a 300-c.c. conical flask, taking care to wash out the filter flask with a little 2.0 per cent. HNO_3, and to keep the bulk of solution under 60 c.c. Add to the solution 10 c.c. of 1.5 per cent. $KMnO_4$, using a pipette, heat to boiling, and maintain at boiling for three minutes, remove the flask from the hot plate, and add, from a wash bottle fitted with a rather large bore jet, sufficient $FeSO_4$ to clear the solution; add not more than 2 c.c. in excess. It is necessary to ensure that there is an *excess* of $FeSO_4$ present; if there is not, a brown precipitate will appear on boiling the solution. Boil the solution for about two minutes. Should a precipitate appear, add a few drops more of $FeSO_4$ until clear, and boil again. The important point at this stage is to see that all oxide fumes are expelled; this usually requires about two minutes' boiling, after which the flask is removed and allowed to cool, either gradually or in cold water. If the latter method is adopted, a little care is necessary to avoid cracking the flasks. When the solution is cool, add concentrated NH_4OH in quantity sufficient to convert the solution into a thin paste, due to precipitation of the iron. The iron precipitate is taken into solution by cautious addition of dilute HNO_3 (1—1), until the solution just becomes clear, then add 10 c.c. in excess; the excess amount is best measured by a pipette or measuring cylinder. The phosphorus is precipitated in exactly the same way as described under the gravimetric method.

To some students who have been trained to cut out such—often called "unnecessary"—details of manipulation as exemplified above—measuring of HNO_3 excess—and in many other paragraphs in the series, it may appear waste of time and much lengthening of the estimations, with a consequent reduction in rapidity, but it is the writer's conviction that errors in analytical work and results are for the most part due to the want of care and attention to little manipulations in a process, and that students should be impressed with the importance of the effect of strict adherence to details, however small they may be. By such adherence to standardisation of details, as well as the major operations of any adopted method of determination, one's confidence in one's work and results is considerably and genuinely increased, solely because guesswork has been eliminated. Further, with practice, the elimination of guesswork becomes not only automatic, but it gives rise to increased rapidity in carrying out a determination.

Attention is drawn to the importance of the amount of excess HNO_3 to use: if there is too great a quantity, low results will occur, while if there is insufficient excess, basic nitrate of iron is precipitated, which may cause the results to be incorrect, usually on the low side if the filtration has been correctly made. The presence of basic iron nitrate is indicated by the phosphorus precipitate having a reddish or brownish tinge, or its presence is more plainly shown after titration of the phosphorus by the fact that the filter pulp has a brown or reddish colour. When the presence of basic iron nitrate is or has been indicated, the result should on no account be reported until a check analysis has been made, which will invariably show the first result to be wrong.

After the phosphorus precipitate has settled out, it is filtered off and washed as previously described, except that the filtering is made by passing the solution through a corrugated 12.5 cm. Whatman No. 1 paper contained in a filter funnel, instead of through a Gooch crucible. Where there are many routine determinations to be made, this method will be found much more convenient than the suction method employing a Gooch crucible. When the precipitate is washed free from acid, transfer filter paper and precipitate back into the precipitating flask. From a burette run $\frac{N}{8}$ KOH in excess into the flask: the presence of excess is shown when, after vigorous shaking of the flask, which has been stoppered with a rubber bung, the solution and pulp is colourless, indicating complete solution of the phosphorus precipitate. The best plan is to add a few c.c. of KOH at a time, and shake rather than run in a large excess and waste standardised solutions. Of course, for certain practices it soon becomes apparent just how many c.c.s of solution to employ to ensure complete solution of the phosphorus. If the iron is low in P, and so only requires a few c.c.s. of KOH, it is advisable to thin the liquid in the flask by adding a little cold distilled H_2O, as if the liquid is too "viscous" (due to the pulp), difficulty will be encountered in determining the "end point" of the titration, due to the tenacious adhering of the KOH to the filter paper.

After dissolving the P, remove the bung and wash it with a jet of cold water, allowing washings to run into the flask. Now add about 6 drops of phenol. solution, and shake round to mix well. From a burette run into the flask $\frac{N}{8}$ HNO_3 until the pink colour commences to fade, then add the acid carefully *a few drops* at a time, and shaking the flask well after each addition, until the colour is just completely discharged. When the titration is completed there should be no trace of pink colour in the solution or in any of the paper pulp: if there is, shake again well, and, if necessary, add a little more—say, 0.10 c.c.—of KOH. If in doubt as to the end point, the solution may be titrated back again by the very careful addition of the KOH solution, until it is slightly pink. The total number of c.c.s. of KOH used minus to total amount of $\frac{N}{8}$ HNO_3 used gives the actual amount of KOH required to react with the phosphorus precipitate. To calculate the result, an estimation is made in precisely the same way as just described on an iron containing a known amount of phosphorus, this having been estimated by the gravimetric method. The c.c.s. of KOH required to react with the P precipitate of this iron (the standard) are divided into the per cent. P it is known to contain: the result is the percentage factor, which × by the c.c.s. of KOH required by the sample, gives the per cent P contained by the latter.

Personal.

MR. T. G. JAMESON has been elected a director of the Hardy Patent Pick Company, Limited, to succeed the late Mr. E. P. Reynolds.

MR. WILLIAM CLARK, a director of Vickers, Limited, has decided to mark the occasion of his having occupied the Presidential chair of the Sheffield Chamber of Commerce for three years by presenting to each past-president a gold badge bearing the arms of the Chamber in enamel.

Wills.

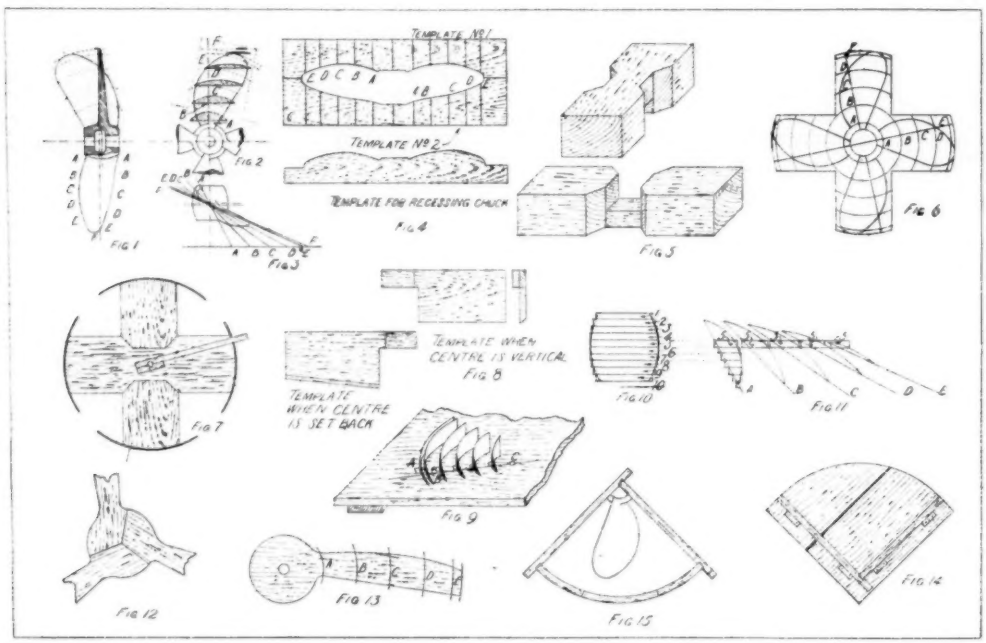
REYNOLDS, E. P., formerly a director of Hardy Patent Pick Company	£6,224
ALLPORT, W. A., of Birchfield Road, Handsworth, metal manufacturer	£5,852
SMITH, A. V., of Newton, Chambers & Company, Limited	£5,283
DE SAUGY, J. A. J. F., lately director and Continental manager of J. & E. Hall, Limited	£12,105
BLACKBURN, G. H., of Dean House, Eastbourne Road, Linthorpe, Middlesbrough, steelworks manager	£11,369
GOULD, W. H. H., a director of Gould's Foundries, Limited, and the Cornish Salvage Company, Limited	£3,227
WOODBRIDGE, W., retired agricultural engineer, founder of the firm of Woodbridge & Company, Long Acre, Bath ...	£11,948

Making Propellers.—II.

By Ben Shaw and James Edgar.

SMALL PROPELLERS.

In modern practice small propellers are usually moulded from solid patterns while large propellers are swept in loam. Loam is the most suitable material for large propeller moulds, because propellers of the same size and pitch are rarely required in sufficient numbers to warrant the making of a loose pattern for sand moulding. Then, again, for the making of one or two castings, not only the expense, but the time involved is against the making of a wood-pattern, unless for a small propeller. Greater accuracy is also obtained when a large propeller is swept in loam. The most carefully-built pattern, even if it does not warp much, may spring when it is being rammed, and, while no hard-and-fast rule can be given when a pattern should be made, it may be as well to mention briefly the conditions which assist in determining whether or not a pattern is made. The authors have made use of loam for making small propellers accurately and, when once the principles are grasped, they are easily applied to any type of propeller. Very small propellers are occasionally cut from a block of solid timber and, if the timber is thoroughly seasoned, a very accurate pattern can be obtained suitable for a few castings. For such patterns we recommend the wood of the lime-tree, which is easily worked, and the pattern retains fine edges given to it after repeated use in the foundry. In the case of a four-bladed propeller, a better job results by half-lapping the stock so that the grain is disposed to give greater strength. When a pattern is required for a larger propeller, say, above 2 to 3 ft. dia., the best method is to build it in laminations. It is quite common to make a sectional pattern consisting of one blade and boss only, which is moved round the necessary number of times to make the mould for the number of blades required, or a sectional pattern may be fixed in



propellers as small as 18 in. in diameter, but, generally speaking, small propellers that are made for launches, pinnaces, pleasure craft, and the like are more or less standardised. For such small craft the propellers are usually made from a full or sectional pattern, and invariably a propeller can be repeated at very short notice by the makers of the vessel. If it is not possible or convenient to obtain a repetition of the original propeller in this way, then a suitable casting is usually made at some jobbing foundry when a loam mould may be used, not necessarily for cheapness, but because of greater convenience. A skilful pattern-maker, it must be remembered, can make a sectional pattern for a propeller, say 2 ft. dia., very quickly, and a casting can be produced by this method quicker than by using a loam mould, but, in a jobbing foundry, when only one patternmaker may be engaged, he can rarely be spared to prepare such a pattern, and consequently, additional work is thrown on the foundry in preparing a loam mould, not because it is necessarily a more economical method, but because the exigencies of the circumstances give no choice. In practice patterns of some form are usually prepared for propellers up to about 3 ft. 6 in. in diameter unless only one casting is required, when the possibilities of loam may be considered though a sectional pattern may finally be made.

The craftsman or apprentice who has had no experience in propeller work can learn much from a core-box from which a number of cores are made, corresponding to the number of blades on the required casting. It will be profitable to consider in greater detail the various methods employed for making such patterns, and for this purpose three views of a propeller are shown in Figs. 1, 2, and 3 which will be used for reference. These views represent a left-handed propeller having four blades cast solid; that is, the whole of the blades with the boss as one casting, which is the type used for small vessels and frequently for large vessels, particularly those of the merchant service. Fig. 2 shows an elevation such as would be seen when looking at the end of the shaft. Fig. 1 defines the sectional shape of the boss, a section of one blade through its centre, an expanded view of a blade surface, and the projected shape at the end elevation of a blade. Fig. 3 indicates the angles defining the pitch at the several distances from the centre at which sections of the blade are given in Fig. 2.

Making the Patterns.

Small patterns up to about 8 or 9 in. dia. can be turned on a face plate and, though they cannot be made very accurately in this way, yet, for some purposes, they suffice. For this method it is necessary to project the end elevation of the blade to the full size of the required pattern. This view is usually given on the drawing supplied, as in the lower part of Fig. 1, but if not it can be

easily developed. Three templates are required to be made, two of which should be made to enclose the projected area of the propeller over the full diameter, as shown in Fig. 4, and the third one shaped for preparing the chuck after one side of the pattern has been turned. The templates used for shaping the pattern should have the various distances marked on them from the centre corresponding to the diameters represented on Fig. 2 at A, B, C, D and E. Patterns for small propellers above about 4 in. dia. should be half-lapped, as in Fig. 5. The side of the square forming the half-lap being just full the size of the boss diameter. The thickness of material will need to be at least equal to the depth of space between the templates, for obvious reasons it is preferable to make it a little thicker. A dotted line is shown about the blade in Fig. 2 indicating the approximate shape of the material. After having glued and secured the two parts they should be accurately centred on the face plate and secured with fine screws through parts of the wood that will be cut away afterwards, when shaping the blades. One side can then be turned in the lathe, using template No. 1 to define the shape and to transfer the various diameters A, B, C, D and E to the work. The next operation is to recess a chuck to receive that part of the work which has been turned. The template for this purpose will ensure accuracy, particularly in depth. When the work has been reset and fixed the turning can be resumed, completing the shape with template No. 2 and marking the various diameters on this side also. The work is now shaped to the sectional area through the longitudinal centre, and the contour of each blade is next required as seen looking in the direction of the end of the shaft. For this purpose the centre lines should be drawn across each face, as shown in Fig. 6, and the various distances transferred from the drawing, using the respective concentric circles to determine the points through which a curve can be drawn, to give the contour of both leading and following edges. While it is better to mark the full shape on one face, for convenience in sawing, it is advisable to mark the leading edges on the other face to show the correct position for finishing the shape. After cutting neatly to shape on the band saw, the face of each blade can be carved between the leading and following edges. Tin templates may be cut and bent to the curve of each diameter to check the surfaces, and the recessed chuck will be useful for supporting the work while paring it. When each face is completed the backs of the blades can be shaped and callipers should be used to check the thicknesses at the various diameters, finally shaping off to the edges. The boss, which should be roughed out to shape when rough-carving the blades, should be the last to be completed.

A Second Method.

Another method which is more accurate and which is in more general use for true screws, up to say 2 ft. dia., is to cut the outer shape to the correct diameter of the pattern and mark on the end of each blade the pitch angle, or, better still, attach guides cut to the requisite angle; then, by means of a template revolving on a dowel at the centre of the boss, as in Fig. 7, carve the face of each blade until the template rides upon the guides and defines the true surfaces. This method is by far the most satisfactory, for patterns cut from the solid timber, whether for full or sectional patterns. Some patternmakers prefer first to cut the stock to the shape of the blade as given in Fig. 2, while others work the faces to the correct pitch and afterwards shape the blades. There is little to choose between the methods excepting that sizes are not usually given on the drawing for the former method and a projected view must be depended upon for obtaining the shape. Invariably the dimensions of the blade are shown on an expanded view, as in the upper part of Fig. 1, and these can be used better after the face of each blade has been shaped to the required pitch. With either method it is convenient to mark the centres on a flat board and secure the prepared stock temporarily to it so that the centre of the half-lap or boss coincides with the intersection of the centre lines on the board, as in Fig. 7. Next fix the guides for the pitch so that their centres correspond with those on the board. The board can be temporarily screwed to the bench for convenience in paring. By adopting this method it is surprising how quickly the pitch surface can be shaped. Marking the shape of each blade is a simple operation, after the faces are finished, and for which the template is particularly useful. For instance, if the template is located so that it is vertical to the centre on the board, a line can be drawn on the blade, since the side of the template radiates from the boss centre. Then, if the various diameters are marked on the template, it is not difficult to transfer them to the blade surfaces with a scriber by simply holding the scriber in each position and rotating the template. The blade shapes can then be formed by marking off the various widths on the concentric arcs and using a piece of flexible steel to pass a curve through them. After cutting out to these shapes, the backs are finished in a similar manner to that already referred to, although, when the propeller is not too small, holes about ¼-in. dia. may be bored at right angles to the face into which pieces of dowel stick may be glued, having a length corresponding to the required thickness of the blade at the various points. If the dowels differ in colour from the pattern they form a reliable guide for finishing off the backs of the blades. We have purposely shown as an example a propeller the blades for which are marked out from a vertical centre, but, frequently, the centre given bears a close relation to the centre of a blade and, when this is the case, it is invariably set back from the vertical. This is a very real stumbling block to many, but, if the principle of the screw is thoroughly grasped, it ought not to be. When the centre is set back it means that the generating line is set back instead of being vertical, and the method of proceeding with the work of shaping such a surface is similar to that already described, excepting that the template, the edge of which corresponds to the generating line, is set back the requisite amount and resembles that shown in Fig. 8.

A Third Method.

The foregoing method is suitable for axially-varying pitched propellers as well as for true screws, but, for those having a radially-varying pitch, it cannot be employed with the same degree of accuracy. In such cases another method is used. This consists of securing a number of tin angle-plates to a board, in correct relation to each other, which serve as a guide for fitting the block until the surface corresponds to them. The preparation of the angles and board is shown in Fig. 9. The angles being cut to suit the pitch at the particular diameter at which each is to be set. Small projection pieces should be left on the angles, as at A and B, for fixing them to the board. A hole should be bored at C and a corresponding dowel in the boss part of the stock, so that the accurate position can be located each time the stock is tried. When the surface is rough cut near to the shape some colouring matter may be applied to the edges of the angles and the surface of the stock tooled until the marks show, when fitted, that it is in contact with the edges of the angles. These marks will then serve as a guide for finishing the surface. The centres for setting out the shape of the blades can be marked from the angles, the shaping of the blades being done the same way as previously mentioned.

What we believe to be the best method of making a pattern for any but very small propellers is to build it, using layers of wood of equal thickness. This method not only disposes the grain of the wood to better advantage than when cut from the solid, but gives definite guidance for shaping the whole pattern without fitting to angles or the use of templates. With regard to the thickness of the layers, much depends on the size of the propeller, but, just as with ordinary circular segmental work, the thinner—within reason—the layers are made the stronger is the completed pattern. It is all-important that joints should be perfect and properly glued. The two drawings Figs. 10 and 11 are necessary. From

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Fig. 10 can be taken the diameters of the boss, and from Fig. 11 the different widths of the blade for the different layers. Skilful drawing of the layers means a subsequent saving of time when face and back of the blades are being shaped off. The principle underlying the building of a propeller pattern in layers is to shape each layer so that the adjoining edges give accurate lines and, when the material is removed between these, a blade of the exact shape is obtained without templates. When a full pattern is to be made and there are four blades, each layer is half-lapped before being marked out. When for a three-bladed propeller a number of methods are adopted for jointing the pieces, a common method being to carry the full diameter of the boss on one piece and half-check the other two into it, as in Fig. 12. In each case, however, it is necessary to make the layers from thicker material than would be used if only one blade is to be made. The method of marking out the layers is best illustrated by reference to Fig. 13. This represents a layer for a single blade corresponding to the layer 5 in Figs. 10 and 11. The diameters at which the angles are marked out are shown by the letters A, B, C, D, and E, and the widths of the layer on these arcs are shown by the little rectangles at A, B, C, D, and E, Fig. 11. When each layer is marked out according to its position —it is, of course, advisable to mark them off in their order to prevent error—they can be assembled. It is quite good practice to bore a hole in the centre of the boss part of each so that they can easily be located with a dowel. As the dowel locates the centre it is only necessary to be careful in setting the layers at one of the diameters near to the tip of the blade and hermaphrodites may be set from Fig. 11 and used for the purpose. As the building of such a blade proceeds each successive layer overlaps the preceding one, and there is a tendency for them to spring unless some support is given. Many pattern-makers retain the scrap pieces from shaping the layers and build up a support for each layer. This is an excellent method and involves little time. It is not necessary to say anything with reference to the shaping off; it is only the corners that are to be removed to form a true sweep between the junction of the layers. In some shops it is the practice to set in a strip of hoop iron across the blade to safeguard against it warping or being rammed out of shape, but this may actually weaken a blade pattern unless it is very large, and, as already explained, it is very seldom that large patterns are made.

Method for Single Blade.

A modification of the above method of construction is necessary for a propeller with separate blades. Each blade is then cast with a flange which fits into and is bolted to a boss. It is perhaps advisable when building a pattern of blade and flange to use two angles, one for the tip and the other for the root or as near to the flange as possible. These angles or guides should be screwed to a building board in correct relation to each other, and the face of the flange and the centre should also be drawn. The flange must be supported with brackets at the correct height from the board. Each layer may be drawn separately and fitted against the flange, sufficient material being left to form a fillet It is advisable to mark the different radii given on the drawing on each layer because, while the face of the blade is built on the templates and is thus accurately obtained, it is necessary to check thicknesses when shaping the back of the blade, and this can only be done from the radii given. These are more easily marked on each layer separately than when the blade is built. It is common practice to check thicknesses by introducing small-diameter dowels cut to the lengths that correspond with the thickness of the blade at the points they are glued in.

Two forms of core-box are made, either of which may meet the requirements of the foundry. These are shown in Figs. 14 and 15. They simply consist of a frame forming an angle of either 90 or 120 deg. at one corner, according to the number of blades required on the propeller. The boss of the blade pattern is cut to fit accurately into this corner. The box must be deep enough to allow a reasonable amount of sand above and below the pattern. Each core is made in two parts in order to extract the pattern, and three or four cores are made and assembled to form the complete mould. A joint block should be made upon which the blade will rest while one part of each core is being made, and these cores form the joints for the remaining parts to be made. Joint blocks are, however, not always supplied, but, with the joint block, a core-box is quite an economical and effective method for making the moulds for propellers up to about 2 ft. or 2 ft. 6 in. dia.

Buying Foundry Coke.

Mr. W. H. Anderson, the Chairman of the Research Committee of the American Southern Metal Trades' Association, has expressed his views on the purchase of foundry coke in an article he has contributed to the *Iron Age*. An abstract of his views is given below.

Whenever trouble occurs in the making of grey-iron castings the foundryman invariably lays it on the coke. In some cases the coke is at fault, but in the majority of cases one finds other items, such as rusty scrap, burnt iron and poor slagging, as the principal reason for foundry troubles.

One foundry using a certain kind of coke will obtain excellent results, while a foundryman across the street will state emphatically that he has tried the same brand of coke and cannot use it. This condition should not be allowed to exist, as a good well-burnt coke giving good results in one shop will give the same results in another, provided the same conditions prevail. If the results are not satisfactory it is time to look into the cupola operation, such as quantity of air delivered, height of fuel bed, height of tuyeres, tuyere ratio, regularity, and size of charges.

For general foundry work the following specifications will protect the buyer: Moisture, less than 3.00; volatile matter, less than 1.15; ash, less than 10.00; sulphur, less than 0.85; and shatter test, above 65 per cent.

The shatter test is important, as it tells how much fine coke to expect, due to handling. A high test coke will run 70 on this test and will give about 2 per cent. of fine coke which cannot be used. Be on guard against a low-shatter coke, as it will crush in the cupola and the yard will have an accumulation of coke breeze.

Recent improvements in the manufacture of by-product coke through the selection of low-ash coals render this material an attractive future in the foundry field. Some of this coke is being produced with an ash content of 6 per cent. and there is no valid reason why the ash should exceed 10 per cent. In view of the enormous quantities of tar, ammonia and benzol wasted annually through the operation of the bee-hive ovens, it is imperative that steps be taken to curtail this waste.

In the course of this investigation a number of defective castings have been inspected; in the majority of cases the coke has been blamed. The inspection revealed that in only 5 per cent. of these had the iron and coke been at fault; 85 per cent. of the defects were due to careless moulding, such as incorrect gating, poor ramming, mis-runs, run-outs, core shifts, etc. The 5 per cent. due to the iron was located in the pig-iron used. This particular consignment was badly oxidised and, on breaking the pigs, the manager found every one unsound and full of blow-holes. This kind of iron will cause a foundry more grief than any ten apprentice moulders, as the whole day's work is likely to be ruined, and the only way of using this iron is at the rate of one pig to the charge. Whenever any oxidised pig-iron shows up, get in touch with the furnace people and reject the truck.

Mr. Ernest Bevin, Secretary of the Transport and General Workers' Union, was the chief speaker at the Rowntree Conference of Managers and Foremen at Oxford last Saturday night.

The Scientific Principles of Centrifugal Casting.*

By Dr. Carl Pardun.

SHOP FUNDAMENTALS AND MECHANICAL PROPERTIES.

German foundry text-books contain very little data on the centrifugal casting process, and information as to the properties of centrifugal castings is entirely lacking. The trade journals, and mostly those of the countries into which the process has been introduced, give descriptions of the several processes. The amount of research work in centrifugal castings is not large, and it is only since 1918 that papers have commenced to appear in the American and English journals. The investigations have been confined principally to piston rings and tubes. Among these published papers may be mentioned those of Cone, Williams, Gillespie, Cole Estep, Cammen and Hurst. Burgess has investigated centrifugally cast-steel cylinders. In all the papers mentioned a considerable increase in mechanical strength has been shown to result due to the method of casting, while, in addition, the graphite segregated is finer and is frequently the cause of the increased strength. But it has not been proved conclusively, according to these papers, what actually causes the increased strength.

The present writer has carried out an investigation into the strength properties of centrifugally-cast pipes, and lays down the working conditions for obtaining successful results. In this he departs from the method followed by previous investigators. The tests were carried out on a testing machine similar to the Briede testing machine.

The cross section and point of rotation of the ladle are so selected that during the whole of the casting period a constant quantity of iron is poured in a given unit of time by the hydraulic tipping movement. When the revolutions of the mould have attained a definite number, the ladle is tipped. As soon as the iron flowing through the

Fig. 1.—Form of Sand-cast Plates.

trough has begun to flow into the sleeve portion, the revolving mould is moved axially. To get this motion, a revolving mould, water-jacketted, is placed on a platform which is moved along rails by hydraulic power. The pipe is formed then by uniform tipping of the ladle, uniform speed of the mould, and uniform axial motion of the latter.

The process is completed when casting lip or gutter has completely emerged from inside the rotary mould and the ladle has been completely emptied except for a very small residue. When the revolving motion has been shut off, the red-hot pipe is lifted out by a special gear. Owing to the slight chilling which takes place on the outside, the pipes have to be annealed for the reconversion of the combined carbon. The whole of the machine system is very slightly inclined to the horizontal with a view to aiding the flow of the iron in the trough. The gauge of the tube can be adjusted by varying the three movements of tipping, revolving and running up, as well as by altering the angle of inclination.

For the purposes of the tests, six sets of from five to ten pipes were cast in the centrifugal machine. The normal dimensions of the pipes were about 12 in. internal diameter, 13 millimetres (½ in.) gauge, and about 17 ft. in length. The different series are lettered A to F. They were used for determining the effect (1) of the rotations (Series A and F); (2) of variation in the silicon content (Series B); (3) of variation in the phosphorus content (Series C); (4) of various casting temperatures (Series D and E).

With each centrifugally cast pipe a test plate was made of the same iron, this being cast upright in a dry sand mould, and having a length of 3 ft. and a thickness of ½ in., corresponding to a pipe 12 in. internal diameter. As Fig. 1 shows, these plates were radiused to an extent of about 6 in. This form had to be selected so that the sand-cast test-bars had the same cross-sectional area as the test-bars cut from the centrifugal-cast tubes. To keep down the annealing costs, plates of the same dimensions were cut from the pipes, as shown in Fig. 1, by means of an electrical cutting-burner; they were then annealed and cut into test-bars. The annealing of the pipe-plates was carried out without air being admitted, and the temperature, as measured by a thermocouple, was 850 to 900 deg. C. The average time of heating was 30 min. The test bars thus have two machined and two unmachined sides, the latter corresponding to the outer and inner sides of the pipe wall. They were subjected in turn to transverse, tensile and impact tests (Table II). The impact test was carried out on a Charpy machine with a tup of 10 kilogram-metres. Each point on the strength curves is based on three to five single tests.

Table I.—*Casting Conditions and Results of Series A and F.*

Pipe No.	Revs. per min.	Casting Temp. °C	Spirals per 1 metre length.	Pressure lbs./ sq. in.
A9	510	1,200	10–12	6.28
A3	456	1,200	12	4.80
A2	435	1,200	13	4.51
A1	435	1,200	14	4.51
A10	435	1,200	?	4.51
A4	395	1,200	32	3.72
A5	380	1,200	31	3.44
A6	365	1,200	30	3.16
A7	312	1,200	26	2.32
A8	245	1,200	21	1.43
F1	520	1,195	—	—
F2	448	1,195	—	—
F3	372	1,200	—	—
F5	327	1,195	—	—
F4	244	1,200	—	—

Note.—It was difficult to detect the spiral formation in above. The spirals were calculated on a mean radius of 158 mm. (about 6¼ inches). Pipes A1 and A10 were not tested.

The casting data referring to the series of rotary tests A and F are contained in Table I. Since the test series A exhibited an unintentionally high sulphur content, the second series F was cast.

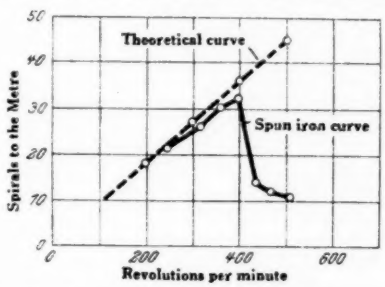

Fig. 2.—Curve of the Spirals of Series A.

Externally there is a difference in the borings or drillings in all the series. The turnings of the centrifugal tubes (pipes) come away in the form of small ringlets, whereas the turnings of the sand-cast plates have the usual sort of dusty appearance. The rotations used lie between 244 and 520 r.p.m. Below 240 r.p.m. the iron in the revolving mould was no longer projected ("thrown"), and no pipe was formed. The machine did not admit of higher revolutions than 520 per minute. By systematically using different numbers of revolutions it was found that from a certain speed in the downward direction spiral lines could be discerned on the outside of the pipes. The combined rotation and longitudinal movement of the mould produce a spiral. The number of spirals or

* Extracted from "Stahl und Eisen," Aug. 28.

turns to 1 metre (40 in.) length of pipe is given in Table I, so far as it was possible to count them. The spirals are measurable with mathematical accuracy up to speeds of 400 r.p.m., but above these speeds they disappear more or less, or their dividing lines become irregular.

The curve in Fig. 2 shows the spirals on a 1-metre length in terms of the revolutions per minute. The curve runs to 400 r.p.m. parallel with and nearly to the same height as the dot-dash curve of the spirals as determined numerically for the various speeds of rotation. The latter are

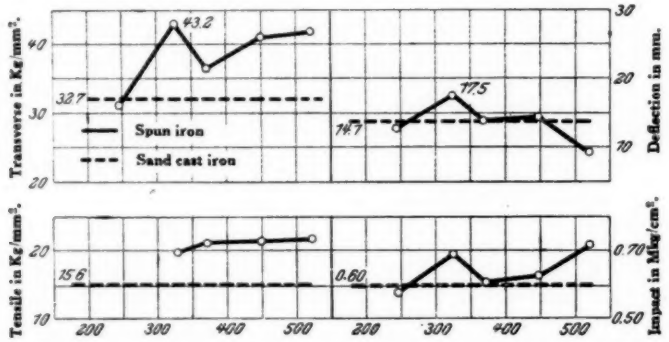

FIG. 3.—STRENGTH CURVES OF SERIES F, WITH INCREASING SPEED OF ROTATION.

obtained from the time of casting and the number of revolutions. In the present case the time of casting per 5 metres length of pipe was 27 seconds, *i.e.*, 5.4 seconds per metre run. At 400 r.p.m. the curve of the centrifugal pipes drops sharply. This phenomenon is of great importance. The highest point of the curve should be regarded as an expression of the critical number of revolutions; it is probably different for each diameter. Its significance is the following:—Whereas up to the critical speed the centrifugal force is just sufficient in order evenly to "spread" the band of liquid, when the critical speed is exceeded the iron commences to "lead" in the mould, thus causing the spirals to disappear or partially to overlap. The advancing liquid band becomes thinner in proportion to the amount of "lead," and hardens prematurely unable to exhibit itself owing to the rigidity of the mass. In the case of projected liquids and fluid metals most kinds of pressure are effective. The radial pressure manifests itself as a pressure on the walls of the tank, while the axial pressure causes the metal to rise in the case of vertical moulds, and to spread in the case of horizontal moulds. The axial pressure is a result of the radial pressure, the particles most remote from the point of rotation having a tendency to escape in zones of lower pressure due to the pressure exerted by the adjacent particles. That is, these particles reach places where there are no particles already. With increasing speed of rotation, and hence increasing pressure, the tendency to this "leading" effect must increase.

The transverse, tensile and shock test results obtained on series F are shown in Fig. 3. The curves show that there is a lower limit for the revolutions below which the strength of the metal becomes lower than in sand-castings made of the same iron. For 12-in. pipes, this limit plainly lies at about 250 revolutions a minute. It is important to note also that the strengths do not increase in proportion to the revolutions. From the minimum revolutions of 250 there is a sharp increase in strength until the maximum is reached at 300 to 325 revolutions, and in some cases this maximum persists, but in others it decreases. It should be

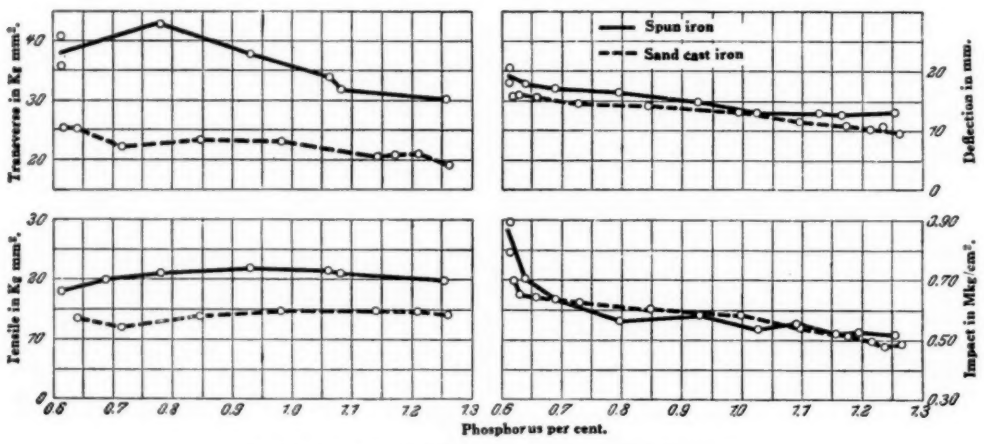

FIG. 4.—STRENGTH CURVES OF PHOSPHORUS SERIES C.

before the main jet travels over it. There is therefore a sort of welding effect produced.

It should be mentioned that the critical revolutions, *i.e.*, the commencement of the "lead," is not only dependent on the radius of rotation and the time of casting, the same phenomenon of "lead" also occurs at higher casting temperatures but at constant speed, as we shall see later when considering series D and F.

In considering this question of "lead," it must be remembered that the centrifugal force acts in two ways, *i.e.*, radially and axially. In actual practice, however, engineers usually only reckon with the radial pressure, as, for example, in calculating flywheels, where the radial pressure is borne in mind that we are dealing here with a wall-thickness of only ½ in. With thin-walled pipes the liquid metal cools much faster with increasing revolutions than when the revolutions are low. After cooling, however, the effect of the centrifugal force on the structure ceases. The curves certainly show an increase in the mechanical properties. Series A led to a similar result.

The effect of varying the proportion of silicon, investigated in series B on 9 pipes, showed itself principally in the chilling action of the iron (rotating) mould. The low-silicon pipes have a perfectly white fracture when cool. A high silicon charge is doubtless necessary for eliminating or reducing the chilling effect of the iron mould.

Speaking from the foundryman's standpoint, a silicon content of less than 1.5 per cent. is not desirable, owing to the chilling effect on the spun mould. One investigator has already shown that the depth of hardness can only be regulated by the silicon content. This also applies to centrifugal castings in spun iron moulds. But, as far as possible, high casting temperatures such as are necessitated when the silicon content is high must be avoided. The upper limit of silicon should be about 3 per cent.

The effect of phosphorus was determined in series C on nine pipes cast with an increasing percentage of 0.62 to 1.26 per cent. of phosphorus, the other elements of the composition remaining the same. The strength curves obtained are shown in Fig. 4. These curves confirm the already observed increase in tensile and bending strength up to a content of 0.8 per cent. P. Above this percentage the strength decreases. The curves running parallel shows that these effects of phosphorus also persist in centrifual castings. For pipe-making a fairly high phosphorus content is necessary to keep the high silicon charge as liquid as possible. A phosphorus content of 1 per cent. has been found to be best, as with higher percentages the hardening effect of this element begins to manifest itself.

The investigations on the effect of different casting temperatures was carried out between 1,190 and 1,240 deg. C. on test series D and E. This temperature interval may be thought too restricted to enable a satisfactory judgment to be formed; but where the other conditions of casting remain constant, it was found in these tests that the varying casting temperature was of such moment that it was only by careful manipulation of the temperature that successive pipes capable of being tested could be obtained at all. The decisive factor is the melting point of the charge used. It is not necessary to have a constant temperature for all kinds of charges. In centrifugal castings the tendency of the metal to flow prematurely or to "lead" increases with the degree of overheating; but the tests showed that it was possible to compensate for this by correspondingly reducing the time of casting.

TABLE II.—*Summary of Percentage Increase in Strength over Sand Castings.*

Test Series.	Transverse strength. Kgs / sq. mm.	Deflection. mm.	Tensile strength. Kg/mm.^{2}	Impact strength. mKg/cm.^{2}
Tests for revolutions				
A	20	—	23	10
—*idem* F	25	—	35	10
Silicon				
Series B ..	56	31	21	38
Phosphorus				
Series C ..	60	23	47	—
Casting Temperature,				
Series D	11	—	15	—
—*idem* E ..	31	19	23	21

No appreciable effect on the mechanical properties was found by the temperature of casting.

Table II is a summary of the increases in strength in all the series tested. Series B and C show the greatest improvement in this respect, these being the series cast at constant revolutions and constant temperature. It follows, then, that the chemical composition of the iron is not the most important, but the adaptation of the revolutions and casting temperature to the composition of the charge.

Publication Received.

South African Railways and Harbours.—This book has been compiled and issued under the authority of the general manager. It contains 158 art pages devoted to a description of the facilities afforded. One chapter (twelve) is devoted to a statistical summary of the working of the railways. We know of no better method of "getting to know" a country other than visiting it than a study of such publications as these.

An Accelerated Electrolytic Corrosion Test.*

By Robert J. Anderson and George M. Enos.

(*Summary.*)

This Paper reports the results of experiments carried out in the development of an accelerated electrolytic test for corrosion. The investigation may be briefly summarised as follows:—

In attempting to develop an accelerated test for corrosion, so-called chemical tests were first made, in which oxygen was introduced into the corroding medium (mine water), by bubbling air through the test vessels. It was found that in this method the weight losses were not higher than those obtained in ordinary long-time immersion tests if the results of both series were reduced to comparable terms.

As the so-called accelerated chemical test did not yield the desired acceleration, a series of experiments was made with an electrolytic test. Certain work of other investigators was first repeated to check it, and the most suitable conditions for carrying out an accelerated electrolytic test were determined after examining the effects of a number of factors that influence results.

Briefly, the method employed for carrying out the accelerated electrolytic test consists in rotating a suitably prepared test piece of the metal or alloy to be tested for corrodibility as the anode in an electrolyte consisting of the corroding medium. The cathode is a platinum wire. A current of amperage sufficient to yield a current density of 0.18 ampere per sq. dcm. of anode area exposed is imposed. The anode is rotated at convenient speed and run until a weighable loss is obtained. The test will also give ordinarily definite indication of the nature of the corrosion, *e.g.*, the kind of coating formed and pitting, if any. With mine water as the electrolyte and ordinary bronze as the anode, sufficient loss can be obtained on an eight-hour run.

Experiments were made in which 42 metals and alloys, that had previously been exposed to a long-time immersion test in acid mine waters, were subject to the accelerated test. Results showed that the order of losses in both tests was the same and that, roughly, the accelerated test was about 10 times as rapid as the long-time test. Depending upon the materials tested, the corroding medium, and the time period of exposure, it is possible to obtain a conversion factor by means of which the results of accelerated electrolytic tests can be translated into terms of long-time immersion tests.

The corroded test pieces in this investigation were examined microscopically for general features, and the nature of the coatings formed was carefully observed, but the great bulk of the results has been omitted from this Paper because of lack of space.

In carrying out future work on this problem, the authors recommend the following: (1) Further study of the factors affecting accelerated electrolytic corrosion testing, and (2) correlation of accelerated electrolytic tests on alloys with actual service test data obtained on the life of metals when exposed to corroding media.

Standard and Analytical Method for Plain and Alloy Steels.

Revised standard methods of chemical analysis for both carbon and alloy steel have been prepared by the American Society for Testing Materials. These methods cover the analysis which are called for in the chemical requirements given in the various specifications of the society for plain carbon and alloy steels. They are issued in two pamphlets: A 33-24, which covers plain carbon steel, and A 55-24, which covers the alloy constituents of alloy steels. The price of the pamphlets is 25c. each, and they can be obtained from the Secretary-Treasurer of the Society, 1315, Spruce Street, Philadelphia, U.S.A.—*Iron Age.*

* A Paper read before the American Society for Testing Materials.

Trade Talk.

Priest Furnaces, Limited, and Sir W. H. Bailey & Company, Limited, have joined the Federation of British Industries.

The statement that Hadfields, Limited, had decided to establish works in Queensland is incorrect. The firm already have works at Sydney and Perth.

The Glasgow Corporation has accepted the offer made recently by Lord Weir to build steel houses, and has decided to authorise the Director of Housing to have 10 houses of the kind erected as an experiment.

Messrs. G. Clay and J. Atkinson, engineers, brass founders, etc., 182, Harris Street, Bradford, trading under the style of Clay & Atkinson, have dissolved partnership. Mr. G. Clay will continue the business.

Thos. W. Ward, Limited, Albion Works, Sheffield, have secured the large contract for structural steelwork for the new smithy and stamp shop for Cravens Railway Carriage and Wagon Company, Limited, Sheffield.

Licences have been granted under the Non-Ferrous Metal Industry Act, 1918, to C. W. Massey, 20, St. Ann's Square, Manchester; and F. C. J. Ubbelohde, Cree House, Creechurch Lane, Leadenhall Street, London, E.C.3.

John Lysaght, Limited, have acquired a substantial interest in the Dominion Sheet Metal Company, at Hamilton, Ontario. Mr. A. T. Enlow, head of the Dominion Company, will, it is stated, continue to act as managing director.

The Wellman-Smith-Owen Engineering Corporation have decided to capitalise £85,000 of the reserve fund and distribute it to shareholders in the form of fully-paid £1 shares and in the proportion of one new share for every two held.

Two box girders, each exceeding 97 ft. in length and having a width of 9 ft. and a weight of 17½ tons, have been successfully carried on the London Midland & Scottish Railway from Reddish to Chesterfield for the Staveley Coal and Iron Company, Limited.

Mr. S. Pulzer, 45, Hatton Garden, London, E.C.1, has converted his business into a limited company, bearing the name of S. Pulzer & Son, Limited. The directors of the company are Mr. S. Pulzer (chairman and managing director) and Mr. L. S. Pulzer.

Automatic and Electric Furnaces, Limited, Elecfurn Works, 173-175, Farringdon Road, London, E.C.1, with a view to further developing their electric furnace business in France and French possessions, have formed La Compagnie Française Wild-Barfield, with offices at 102, Rue Faubourg Poissonnière, Paris.

John Summers & Sons, Limited, Hawarden Bridge Ironworks, Shotton, have closed down their No. 1 mill. The men reported at the Shotton Labour Exchange, and in each case were certified to be out of work "owing to the impossibility of producing steel in competition with imported material from the Continent."

Owing to the unsatisfactory outlook in the pig-iron industry, and the heavy assessments on the idle blast-furnace plant, the directors of the Dalmellington Iron Company, Limited, have under consideration the question of the dismantlement of the furnaces. A new mine is being opened up at Pennyvenie, and another pit is to be sunk in the same district.

A visit of inspection to the Carron Company's works at Carron, Falkirk, was paid on Saturday last by over 100 members of the Glasgow and West of Scotland Association of Foremen Engineers and Draughtsmen. The visitors were received by Mr. John Mercer, manager of the engineering department, and were shown over the extensive works by numerous officials.

A general discussion on the physical chemistry of igneous rock formation is to be held in the rooms of the Geological Society, Burlington House, London, on Wednesday, October 22. The meeting is being organised under the joint auspices of the Faraday Society, the Geological Society, and the Mineralogical Society. A general introduction will be contributed by Dr. J. S. Flett, and papers are expected from Professor C. H. Desch, Dr. J. W. Evans, Professor J. W. Gregory, Mr. A. F. Hallimond, Professor Paul Niggli, Dr. A. Richardson, Dr. A. Scott, Mr. G. W. Tyrrell, and Dr. W. E. S. Turner.

Several new locomotive orders are recorded this week. The Buenos Aires Great Southern Railway have ordered 55 locomotives from British firms, 25 to be built by the Vulcan Foundry, Limited, Newton-le-Willows; 15 by Beyer, Peacock & Company, Limited, Gorton Foundry, Manchester; and 15 by the North British Locomotive Company, Limited, Glasgow. The Nizam's Guaranteed State Railways have placed contracts for five locomotives with Beyer, Peacock & Company, and for two with the Vulcan Foundry. Sir W. G. Armstrong, Whitworth & Company, Limited, are to begin shortly the construction of 30 powerful main-line locomotives for the South Australia Government Railways.

The Mines Dominales Francaises du Bassin de la Sarre, which, under the Treaty of Versailles, were ceded to France by Germany for 15 years, have placed an order for 89 turbine furnaces. It may be stated that the Turbine furnace, which is, of course, a British invention and owned by the Turbine Furnace Company, Limited, 238B, Gray's Inn Road, London, W.C., is controlled on the Continent by the Cie. Continentale des Foyers Turbine, whose head offices are at 29, Rue de l'Evêque, Brussels, and the Compagnie Française des Foyers Turbine, 24, Rue de Caumartin, Paris, and further extensive developments on the Continent are expected.

While existing contracts for British-built Riley stokers will be completed by Charles Erith & Company, all future contracts will be made by the Riley Stoker Company, Limited, which has acquired the sole British rights for the Riley, Harrington, Jones & Murphy stokers, corresponding to those made in America by the Sanford Riley Stoker Company, and in France by the Fama Company. Improvements have recently been incorporated in the stoker, increasing its range of fuels, and its overload capacity and efficiency, while retaining the moving-grates and rocker-dump, etc. One recent contract is for nine Riley stokers, each capable of burning 30,000 lb. coal hourly in its archless furnace under a 23,600 sq. ft. boiler.

In refuting statements which have been made that the railway companies neglect British industry, an official of the Railway Companies' Association points out that among the orders placed during the present year by the London Midland and Scottish Railway have been 120,000 tons of steel rails, 50 locomotives, 250 boilers, 1,000 steel-framed wagons, four new steamers, and a great deal of other railway material. The Great Western Railway has ordered 32,000 tons of steel rails, 20,000 tons of steel chairs and a large number of tyres, etc., in addition to two new cross-Channel steamers; the Southern Group have ordered 40,000 tons of steel rails, fishplates, chairs, etc., five new steamers and large quantities of electrical equipment, and the London and North-Eastern Group a large number of locomotives, boilers, rolling stock and other equipment. The new extension works of the Underground Railways have also been responsible for the ordering of thousands of tons of tunnel segments, bolts and nuts, rails, fishplates, etc., at various centres of the industry.

Obituary.

Mr. C. R. Johnson, of 1, Agden Road, Sharrow, Sheffield, died on September 21. Mr. Johnson, who was 64 years of age, was senior partner in the firm of Johnson & Playfair, Limited, wire manufacturers, of Owlerton. He was formerly managing director of Ramsden, Camm & Company, Limited, of Brighouse, but in 1914 he, with Mr. Playfair, established the business at Owlerton.

Mr. H. K. G. Bamber, for many years a director of the Associated Portland and British Portland Cement Companies, was killed on Saturday last in a motor-car accident near Gravesend. His brother, Mr. Montague Bamber, died subsequently from his injuries. Twenty-four years ago Mr. H. K. G. Bamber became a managing director of the Associated Portland Cement Company, and about twelve years later of the British Portland Cement Company, in addition to supervising the works on the Thames and Medway.

Mr. D. Bremner, who was actively identified for many years with the Clyde shipbuilding industry, died last week. Mr. Bremner, who was a native of Wick, entered the service of James & George Thomson, Clydebank, at an early age, ultimately becoming manager of the commercial department. He remained at Clydebank for a good many years after the establishment was acquired by John Brown & Company, Limited, of Sheffield, but left to become a partner in the firm which founded the Clyde Shipbuilding and Engineering Company, Limited, of Port-Glasgow. After severing his connection with this firm, he acquired the Port-Glasgow works of David J. Dunlop & Company, which he reconstituted as Dunlop, Bremner & Company, Limited, and managed for several years. Later he sold this undertaking to Lithgows, Limited, also of Port-Glasgow, and some time afterwards he and Mr. H. M. Macmillan established the Blythswood Shipbuilding Company, Limited, of Scotstoun. Later still he laid out for the Lloyd Royal Belge (Great Britain), Limited, the shipyard at Scotstoun now owned and operated as the Jordanvale Yard of Barclay, Curle & Company, and he managed that establishment until the Belgian firm closed down. Mr. Bremner, who was a director of the Steel Company of Scotland, Limited, was in his 69th year.

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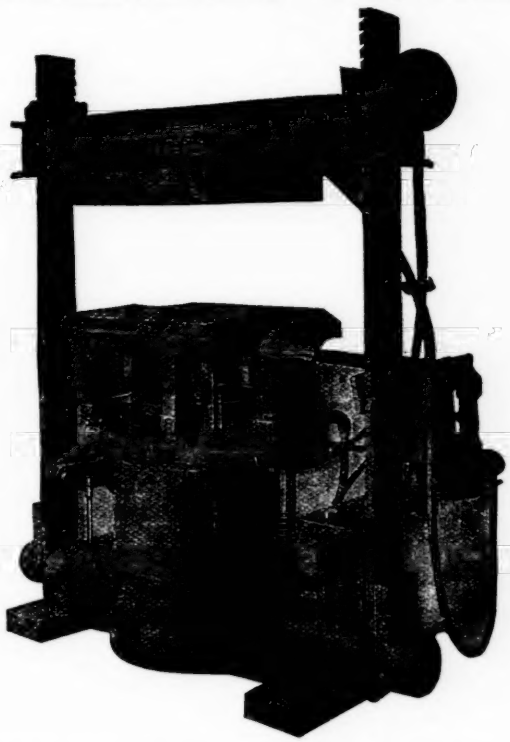

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IRON AND STEEL MARKETS.

Pig-iron.

MIDDLESBROUGH.—Earlier anticipations of a revival of buying interest in pig-iron at the opening of the autumn period have so far been disappointed, Tees-side reports indicating a continuance of inactivity in the Cleveland market, notwithstanding the recent steady decline in quotations, which must surely by now have reached rock-bottom levels. In the home trade, the foundries generally are badly off for orders, conditions directly traceable to the shipbuilding slump, the adverse effect of which upon the whole of the iron and steel trade of the North-East Coast is very pronounced. Consequently it is not surprising that pig-iron consumers are very wary, and continue to be very reluctant to do other than buy small quantities rfom hand to mouth. At this week's market, makers generally adhered to 81s. for No. 3 G.M.B., and it was reported that one or two sales had been made at that figure. These, however, could only have been small lots, and there is no doubt that bargains could be made for any substantial parcels. No. 1 is round about 86s., No. 4 foundry 80s., and No. 4 forge 79s. per ton.

Some slight improvement is reported in the hematite position, with inquiries better, while sales, though in the aggregate not amounting to a great deal, are certainly better than those of foundry iron. There is, however, very little export inquiry. Quotations are unchanged, East Coast mixed numbers standing at 89s., and No. 1 89s. 6d. per ton. On the North-West Coast some price-shading is reported to secure orders, and Bessemer mixed numbers are 1s. 6d. per ton lower than the figures at which they are nominally quoted, viz., 104s. per ton, delivered at Glasgow, 110s. at Sheffield, and 115s. at Birmingham.

LANCASHIRE.—Corresponding with the conditions now general throughout the trade, pig-iron markets in this district continue inactive, consumers holding off buying in the belief that still lower prices will be available before the autumn is far advanced. So long, however, as there is no Continental demand for Cleveland iron, there can scarcely be any improvement in that price, and with Cleveland iron at 82s. at the furnaces, the Midland iron cannot advance beyond the present price. Scotch iron is in very small request locally at the moment, as the ordinary ironfounder cannot afford the price, and the textile machinery makers have not much work yet. Scotch foundry iron is quoted at Manchester at 107s. to 108s. per ton, but it has been done at less.

THE MIDLANDS.—Business in the foundry pig section at Birmingham market last week was on a limited scale, with prices having an erratic tendency. Black Country ironfounders are by no means cheerful, and are perfectly content to limit their purchases to week-by-week supplies. It is not thought that if prices fall still lower it would bring any appreciable amount of new business. Ruling quotations are as follow:—Derbyshire No. 3 foundry, 85s. to 87s. 6d.; Staffordshire No. 3 foundry, 87s. 6d.; Northants No. 3 foundry, 80s. to 82s. 6d.

SCOTLAND.—The outlook in the Scottish iron trade continues disappointing, but so far there has been no reduction in the number of furnaces producing pig-iron in this district, notwithstanding the fact that prices are again easier, No. 3 foundry being quoted at 91s. per ton at the furnaces. There is no improvement in the demand, and business continues to be chiefly in small lots for quick delivery, consumers having no courage to come into the market and buy forward.

Finished Iron.

Unfortunately there is nothing more encouraging to say concerning this branch of the industry. Apart from a fair demand without real pressure for marked bars, there is very little doing. Except for special purposes where good iron is essential, the prices ruling are all much too high to compete with the cheap steel offered, and there does not seem to be much chance of the idle mills being restarted. Great difficulty is being experienced in maintaining regular operations in the mills that are at work. Makers who came down to £12 15s. for crown bars obtained a few small orders, but nothing appreciable. Firms who have always been in the front rank continue to quote £13, but the results are not encouraging; their sales are very limited. Makers of commoner qualities are now up against £7 f.o.b. Antwerp for Belgian No. 3. What with this and the very cheap re-rolled foreign steel, they are having a very lean time. The general demand for iron strip does not increase.

Steel.

At Sheffield the steel market remains very quiet, and the demand for acid and basic billets is at a minimum. Open-hearth steel is almost at a standstill, but some makers of crucible steel report some quite satisfactory orders. The market for semis is still dominated by Continental prices, the Germans having now joined in the business at £6 5s. The trade, however, is not entirely captured by the Continental makers to the exclusion of the British, who continue to do a small business at a very much better price (between £7 10s. and £7 15s.), but for all practical purposes the market is in the hands of the foreigner.

Scrap.

From a general standpoint, the position in the scrap metal trade continues extremely unsatisfactory, the recent substantial decline in prices of the principal qualities having failed to stimulate buying to any appreciable extent, and demand is mostly lifeless. In Lancashire, for example, really good broken machinery cast-scrap can be bought at about 85s. per ton, and in relation to pig-iron it ought to be worth 95s. For common cast-scrap 82s. 6d. per ton has to be accepted, and there is no large sale for it at that price. In the Scottish markets also business continues quiet, machinery cast-iron scrap, in pieces not exceeding 1 cwt., suitable for foundries, making 86s. 6d., with cast-iron railway chairs at the same figure. Ordinary cast-iron scrap, in handy pieces, is being offered freely at 82s. 6d. per ton, with few buyers. The above prices are all per ton, delivered f.o.t. consumers' works.

Metals.

Copper.—The tendency of standard values, though inclined to slightly lower levels, is, on the whole, fairly steady and without indications unfavourable to developments in the direction of increased activity in the near future. Consumptive demand at home is about normal for this period of the year, while the progressive stabilisation of Continental exchanges may be marked as a bull point by speculative interests. The issue of the monthly statistics, now due, may also suggest a more encouraging prospect for an early revival of market activity. Current quotations:—*Cash*: Thursday, £62 5s.; Friday, £62 5s.; Monday, £62 5s.; Tuesday, £62 5s.; Wednesday, £62.

Three Months: Thursday, £63 5s.; Friday, £63 5s.; Monday, £63 5s.; Tuesday, £63 5s.; Wednesday, £62 17s. 6d.

Tin.—With buying on a somewhat restricted scale, the market for standard tin has developed further weakness, and although fluctuations in values have been confined within comparatively moderate compass, the tendency is fairly steady in the main. The American tinplate trade is reported to be actively engaged, but there is still plenty of room on this side for further business. Possibly a little less juggling with prices would help matters. The tin position looks healthy enough. The shipments for this month should be lighter, and the Eastern pooled surplus is now rapidly dwindling, current market rates being favourable still to its disposal, and after the severe fall there should be room for some improvement. Current quotations:—*Cash*: Thursday, £234 5s.; Friday, £233 10s.; Monday, £236 15s.; Tuesday, £239 5s.; Wednesday, £238 15s.

Three Months: Thursday, £236 15s.; Friday, £235 15s.; Monday, £239 5s.; Tuesday, £241 5s.; Wednesday, £241.

Spelter.—The tone in this section of the metal markets of late has been fairly firm, values, however, having a slightly downward tendency. The Continental inquiry has been more encouraging, while Belgium has offered only meagre quantities of spelter, and with Germany willing to take all that is available, supplies are becoming increasingly difficult to obtain, especially as Belgian producers are said to be well sold to the end of the year. Current quotations:—*Ordinary*: Thursday, £32 11s. 3d.; Friday, £32 13s. 9d.; Monday, £32 12s. 6d.; Tuesday, £32 12s. 6d.; Wednesday, £32 15s.

Lead.—In the market for soft foreign pig business has been uneventful, with quotations within a moderate compass, though tending to slightly lower values. The absorption of lead by the consuming industries is certainly not so heavy as was the case earlier in the year, heavy, and the large influx of supplies during the last few months has been fairly well taken up. Current quotations:—*Soft foreign (prompt)*: Thursday, £32 15s.; Friday, £32 13s. 9d.; Monday, £33; Tuesday, £33; Wednesday, £33 3s. 9d.